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(54) GLASS SUBSTRATE FOR INFORMATION RECORDING MEDIUM AND MAGNETIC INFORMATION RECORDING MEDIUM USING THE SAME

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a substrate for an information recording medium which is excellent in scratching resistance, is light in weight and is high in destruction toughness and a magnetic information recording medium using the same.
SOLUTION: The glass substrate for the information recording medium which is ≤7 μm1/2 in brittleness index in an atmosphere where the brittleness index in water is ≤12 μm-1/2 and/or the dew point is ≤-5° C or the glass substrate for the information recording medium consisting of glass which contains 40 to 75% SiO2, 2 to 45% B2O3 and/or Al2O3 and 0 to 40% R'2O (R' is at least one kind selected from the group consisting of Li, Na and K) and in which the total content of SiO2, B2O3, Al2O3 and R'2O is ≥90% and the magnetic recording medium having at least a magnetic recording layer on this glass substrate.

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JAPANESE [JP,2002-358626,A]

CLAIMS DETAILED DESCRIPTION TECHNICAL FIELD PRIOR ART EFFECT OF THE INVENTION TECHNICAL PROBLEM MEANS EXAMPLE

[Translation done.]

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CLAIMS

[Claim(s)]
[Claim 1] The glass substrate for information record media characterized by an underwater brittleness index value being 1/2 or less [12 micrometers -].
[Claim 2] The glass substrate for information record media characterized by a brittleness index value [in / in a dew-point / an ambient atmosphere -5 degrees C or less] being 1/2 or less [7 micrometers -].
[Claim 3] The glass substrate for information record media characterized by for an underwater brittleness index value being 1/2 or less [12 micrometers -], and a brittleness index value [in / in dew-point / ambient atmosphere -5 degrees C or less] being 1/2 or less [7 micrometers -].
[Claim 4] By mol %, while more SiO(s)2, and B-2s O3 and/or aluminum 2O3 than 65% are included with the total quantity 0 - 20% (at least one sort as which R is chosen from Mg, calcium, Zn, Sr, and Ba) of RO(s), R'2O(at least one sort as which R' is chosen from Li, Na, and K) 0 - 28%, The glass substrate for information record media according to claim 1, 2, or 3 with which the sum total content of the above-mentioned component consists of glass which is 95% or more, including TiO2 0-10% and ZrO2 0-10%.
[Claim 5] At mol %, it is SiO2. 40 - 75%, B-2 O3, and/or aluminum 2O3 Glass substrate for information record media characterized by the sum total content of SiO2, B-2s aluminum [O3 and] 2O3, and R'2O consisting of glass which is 90% or more, including 2 - 45%, and R'2O(at least one sort as which R' is chosen from Li, Na, and K) 0 - 40%.
[Claim 6] The glass substrate for information record media according to claim 5 whose underwater brittleness index value is 1/2 or less [12 micrometers -].
[Claim 7] The glass substrate for information record media according to claim 5 or 6 whose brittleness index value [in / in a dew-point / an ambient atmosphere -5 degrees C or less] is 1/2 or less [7 micrometers -].
[Claim 8] The glass substrate for information record media given in claim 1 whose Young's modulus is 70 or more GPas thru/or any 1 term of 7.
[Claim 9] The glass substrate for information record media given in claim 1 whose rigidity is 20 or more GPas thru/or any 1 term of 8.
[Claim 10] The glass substrate for information record media given in claim 1 which viscosity becomes from the glass which has the field which is 1 or more Pa-s in the temperature field beyond liquid phase temperature thru/or any 1 term of 9.
[Claim 11] The glass substrate for information record media given in claim 1 which a coefficient of thermal expansion becomes from the glass which is more than 60x10-7/degree C in the temperature of 100-300 degrees C thru/or any 1 term of 10.
[Claim 12] The glass substrate for information record media given in claim 1 which does not have a chemical-strengthening layer thru/or any 1 term of 11.
[Claim 13] The glass substrate for information record media given in claim 1 which has a chemical-strengthening layer thru/or any 1 term of 11.
[Claim 14] The magnetic information record medium characterized by having a magnetic-recording layer at least on the glass substrate for information record media given in claim 1 thru/or any 1 term of 13.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the magnetic information record medium which used the glass substrate for information record media, and it. In more detail, this invention excels in abrasion-proof nature and is lightweight, and it is related with the magnetic information record medium using the glass substrate for information record media with big fracture toughness, and this glass substrate for information record media represented by the hard disk.
[0002]
[Description of the Prior Art] Conventionally, aluminum, glass, the ceramics, etc. have been used as a substrate ingredient for magnetic information record media. According to current, size, or an application, aluminum and glass are mainly put in practical use. In it, a glass substrate has little surface discontinuity, and since smooth nature and surface hardness are excellent, the use range is being expanded every year. As glass used as a substrate for magnetic information record media, the chemically strengthened glass by the ion-exchange method, glass ceramics, etc. are known. As chemically strengthened glass, it is a weight % display and the glass substrate for magnetic disks by which formed the compressive-stress layer on the surface of the glass substrate, and the chemical strengthening was carried out by the ion-exchange method according the glass containing 2:50 - 65% of SiO(s), 2O3:0.5 - 14% of aluminum, R2O(however, R alkali-metal ion):10-32%, ZnO:1-15%, and B-2O3:1.1-14% to alkali ion is indicated by JP,1-239036,A, for example. Moreover, as glass ceramics, it is in a U.S. Pat. No. 5391522 specification, for example, By weight % display, 2:65 - 83% of SiO(s), Li2O:8-13%, K2O:0-7%, MgO: — 0.5 - 5%, ZnO:0-5%, and PbO:0-5% — however MgO+ZnO+PbO: The glass-ceramics substrate for magnetic disks including Li2O and a 2SiO2 crystal-grain child detailed as a main crystal is indicated 0.5-5% and P2O5:1-4% including 2O3:0 - 7% of aluminum, and 2O3:0 - 2% of As2O3+Sb(s).
[0003] However, since information recording apparatus, such as a magnetic disk represented by the hard disk in recent years, are asked for the densification of record, and the writing of data and improvement in the speed of reading, improvement in the speed of disk rotation is needed for them. Although the rotational speed of a current disk is 7200rpm extent, accelerating more than 15000rpm or it in the future is expected. This demand is considered to become still stronger by especially the hard disk drive for servers that processes a lot of data. However, if the rotational frequency of a record medium is raised, a deflection will arise in a record medium, resonance will become large, and the danger that the front face of a record medium will collide with the magnetic head, and will read, and an error and the magnetic head will crash will become high. Therefore, since distance (surfacing distance) of the magnetic head and a record medium cannot be made small to some extent below in the present record medium, it is becoming the inhibition factor of the increment in recording density of a magnetic recording medium. The deflection of this record medium and the problem of resonance are solved by use of the rate substrate ingredient of high elasticity.
[0004] However, the motion to which it tends to thicken a substrate and tends to correspond to high-speed rotation-ization of a hard disk since an elastic modulus is 80 - 100GPa extent in 72GPa extent and cannot respond to high-speed rotation-ization yet is coming out of a glass substrate the aluminum substrate generally used so far. Since the increase of thickness of a substrate is accompanied by the increase of weight, the power [exhausting] of rotation[high-speed]-izing becomes large. Therefore, a substrate ingredient lighter than an aluminium alloy with a large consistency (2.76 g/cm3) is called for from a commercial scene. Moreover, an aluminum substrate has a possibility of denting the front face of a record medium in the collision of a high-speed rotation substrate and the magnetic head, in order that plastic deformation may tend to break out [surface hardness] low far from glass. On the other hand, although the glass substrate excels the aluminum substrate in an elastic modulus, surface hardness, and surface smooth nature, since it is weaker than an aluminum substrate, it is easy to get damaged, and existence of few blemishes formed in a production process leads to breakage. For example, when using glass as a magnetic-disk substrate, many processing processings, such as circular processing and heart omission and inside-and-outside periphery side processing, are needed. During these processing processings, too, many blemishes which can serve as a destructive radix point in the glass edge section etc. occur, and few blemishes formed only in a production process at the time of wearing and the other handling by the spindle lead to substrate breakage. This problem becomes more important especially with improvement in the speed of magnetic-disk rotation. In order to solve these problems, it is

necessary to offer high, the drag force, i.e., fracture toughness, over destructive advance of the substrate glass with which a consistency cannot get damaged easily small, or glass, substrate glass.
[0005]
[Problem(s) to be Solved by the Invention] This invention is the basis of such a situation, and when the consistency which can respond to rotation[high-speed]-izing or a high recording density-ized trend is small, and it excels in abrasion-proof nature and a blemish cannot be attached easily, it aims at offering the drag force to destructive advance, i.e., the glass substrate for information record media with big fracture toughness, and the magnetic information record medium using it.
[0006]
[Means for Solving the Problem] In order that this invention persons may attain said purpose, as a result of repeating research wholeheartedly, the glass substrate below a value with the brittleness index value measured in underwater and/or a desiccation ambient atmosphere or the glass substrate which consists of glass of a specific presentation came to complete this invention for that purpose being suited as a glass substrate for information record media based on a header and this knowledge.
[0007] Namely, the glass substrate for information record media with which a brittleness index value [in / in this invention / (1) underwater] is characterized by being 1/2 or less [12 micrometers -] (Glass substrate for information record media I is called hereafter.) The glass substrate for information record media characterized by a brittleness index value [in / in (2) dew-points / an ambient atmosphere -5 degrees C or less] being 1/2 or less [7 micrometers -] (the glass substrate II for information record media is called hereafter.) A (3) underwater brittleness index value is 1/2 or less [12 micrometers -]. And the glass substrate for information record media characterized by a brittleness index value [in / in a dew-point / an ambient atmosphere -5 degrees C or less] being 1/2 or less [7 micrometers -] (the glass substrate III for information record media is called hereafter.) By (4) mol %, while more SiO(s)2, and B-2s O3 and/or aluminum 2O3 than 65% are included with the total quantity 0 - 20% (at least one sort as which R is chosen from Mg, calcium, Zn, Sr, and Ba) of RO (s), R'2O(at least one sort as which R' is chosen from Li, Na, and K) 0 - 28%, The above (1) which the sum total content of the above-mentioned component becomes from the glass which is 95% or more, including TiO2 0-10% and 20 - 10% of ZrO(s), (2), or the glass substrate for information record media given in (3), [0008] (5) At mol %, they are 2 2 - 45% of SiO(s), and R'2O (it Li(s) R'). 40 - 75%, B-2 O3, and/or aluminum 2O3 The glass substrate for information record media characterized by the sum total content of SiO2, B-2s aluminum [O3 and] 2O3, and R'2O consisting of glass which is 90% or more, including 0 - 40% per sort [at least] chosen from Na and K (the glass substrate IV for information record media is called hereafter.) The glass substrate for information record media given in the above (5) whose (6) underwater brittleness index value is 1/2 or less [12 micrometers -], (7) The above (5) whose brittleness index value [in / in a dew-point / an ambient atmosphere -5 degrees C or less] is 1/2 or less [7 micrometers -], or the glass substrate for information record media given in (6), (8) The above (1) whose Young's modulus is 70 or more GPas thru/or the glass substrate for information record media given in any 1 term of (7), (9) In the temperature field beyond the above (1) whose rigidity is 20 or more GPas thru/or the glass substrate for information record media given in any 1 term of (8), and (10) liquid-phase temperature The above (1) which viscosity becomes from the glass which has the field which are more than 1Pa and s thru/or the glass substrate for information record media given in any 1 term of (9), [0009] (11) The above (1) which a coefficient of thermal expansion becomes from the glass which is more than 60x10-7/degree C in the temperature of 100-300 degrees C thru/or the glass substrate for information record media given in any 1 term of (10), (12) The above (1) which does not have a chemical-strengthening layer thru/or the glass substrate for information record media given in any 1 term of (11), (13) The above (1) which has a chemical-strengthening layer thru/or the glass substrate for information record media given in any 1 term of (11), And the magnetic information record medium characterized by having a magnetic-recording layer at least on the glass substrate for information record media (14) above (1) thru/or given in any 1 term of (13) is offered.
[0010]
[Embodiment of the Invention] There are four modes, i.e., glass substrate I-IV for information record media, in the glass substrate for information record media of this invention. A brittleness index value [in / in glass substrate I for information record media of this invention / underwater] is 1/2 or less [12 micrometers -] glass substrate. A brittleness index value underwater [this] serves as a glass substrate which is not weak, so that that value is low. A brittleness index value underwater [this] is 1/2 or less [8 micrometers -] still more preferably 1/2 or less [9 micrometers -] more preferably 1/2 or less [10.5 micrometers -]. When an underwater brittleness index value is such a value, the destruction at the time of polish processing of a glass substrate performed in the condition of having flooded with polish liquid, and handling of the glass substrate in the condition of having wetted wet in polish liquid and a penetrant remover stops being able to happen easily.
[0011] A brittleness index value [in / glass substrate / II / of this invention / for information record media / in a dew-point / an ambient atmosphere -5 degrees C or less] is 1/2 or less [7 micrometers -] glass substrate. This index value is 1/2 or less [4 micrometers -] still more preferably 1/2 or less [5 micrometers -] more preferably 1/2 or less [6 micrometers -]. When a brittleness index value [in / in a dew-point / an ambient atmosphere, i.e., a desiccation ambient atmosphere, -5 degrees C or less] is such a value, in a desiccation ambient atmosphere, destruction cannot take place easily at the time of handling the glass substrate for information record media, and the time of use of the information record medium using this glass substrate.

[0012] A brittleness index value [in / in the glass substrate III for information record media of this invention / underwater] is 1/2 or less [12 micrometers -], and a brittleness index value [in / in dew-point / ambient atmosphere -5 degrees C or less] is 1/2 or less [7 micrometers -] glass substrate. A brittleness index value underwater [above-mentioned] is 1/2 or less [8 micrometers -] still more preferably 1/2 or less [9 micrometers -] more preferably 1/2 or less [10.5 micrometers -], and the brittleness index value in the ambient atmosphere of the -5 degrees C or less of the above-mentioned dew-points is 1/2 or less [4 micrometers -] still more preferably 1/2 or less [5 micrometers -] more preferably 1/2 or less [6 micrometers -]. This glass substrate III is equipped with the property of both said glass substrates I and II, and even if it uses it for the bottom of what kind of environment or handles, destruction cannot take place easily.
[0013] ["a journal OBU JI American chemical society (J. Am.Chem.Soc.)" which adopts the brittleness index value B proposed by B.R.Lawn and others as a brittleness index value of said glass substrate in this invention -- the 62nd volume, and the 347th - 350-page (1979)]. Here, the brittleness index value B is defined from the Vickers hardness value Hv and the fracture toughness value Kc of glass to formula B=Hv/Kc.
[0014] The Vickers hardness value Hv and the fracture toughness value Kc of glass can do ** measured by the approach of stuffing the sharp diamond indenter of a Vickers hardness meter into glass. That is, the degree of hardness of glass is called for by the degree type from the magnitude of the indentation of the indenter which remains on the surface of glass, when the Vickers indenter is pushed in.
[0015]
[Equation 1]

$$Hv = 1.8544 \times \frac{P}{(2a)^2}$$

[0016] Here, P is the pushing load of the Vickers indenter and a is the diagonal line length of the Vickers indentation. On the other hand, the fracture toughness Kc of glass is searched for by the degree type from the magnitude of the indentation of the indenter which remains on the surface of glass, and the die length of the crack generated from the corner of an indentation, when the Vickers indenter is pushed in.
[0017]
[Equation 2]

$$Kc = 0.026 \frac{E^{\frac{1}{2}} P^{\frac{1}{2}} a}{C^{\frac{3}{2}}}$$

[0018] Here, E is the Young's modulus of glass, and the die length of the crack which generates C from the corner of an indentation. The requirement for calculating Kc correctly is that a C/a ratio becomes large 2.5 or more.
[0019] the approach shown in JP,10-158028,A which indicates this example of a comparison in this invention in order to compare with the below-mentioned example of a comparison although the brittleness index value B of glass was computed by Hv and Kc which were calculated above to B=Hv/Kc — namely [0020]
[Equation 3]

$$B = 2.39 \times \left[\frac{C}{\alpha}\right]^{\frac{3}{2}} P^{\frac{1}{4}}$$

[0021] The value which was boiled and was computed more is adopted.
[0022] Since most differences with the value of the brittleness evaluated by the value and Hv/Kc equation of the brittleness using the formula shown in JP,10-158028,A are 5% or less, even if it uses the equation shown in JP,10-158028,A, it can evaluate correctly. The formula shown in JP,10-158028,A in fact used Lawn's and others Hv/Kc formula as the base, and was drawn, and its fundamental concept is the same.
[0023] An underwater brittleness index value drops the waterdrop of pure water on a sample front face, after 30 seconds, pushes in the Vickers indenter from on the waterdrop, and introduces an indentation and a crack. After that, it is immersed into pure water, a sample is taken out 24 hours after immediately, water is wiped off, and it is the value which measured and computed the magnitude of an indentation and a crack immediately. Moreover, while a brittleness index value [in / in a dew-point / an ambient atmosphere -5 degrees C or less] measures the dew-point of the sample circumference under desiccation nitrogen-gas-atmosphere mind and checks that this dew-point is -5 degrees C or less, the Vickers indenter is pushed in and an indentation and a crack are introduced, and it is the value computed by having measured those magnitude.
[0024] Since it has the above brittleness index values, when a blemish cannot be attached easily, since a chemical strengthening equivalent to conventional glass is also possible, the glass substrates I, II, and III for information record media of this invention can decrease breakage in use sharply as the breakage in a production process, and a product.
[0025] As such glass substrate I-III, it is mol% as a glass presentation. While more SiO(s)2, and B-2s O3 and/or aluminum 2O3 than 65% are included with the total quantity 0 - 20% (at least one sort as which R is chosen

from Mg, calcium, Zn, Sr, and Ba) of RO(s), What the sum total content of the above-mentioned component becomes from the glass which is 95% or more can be mentioned including R'2O(at least one sort as which R' is chosen from Li, Na, and K) 0 - 28%, TiO2 0-10%, and ZrO2 0-10%.
[0026] this glass presentation — setting — the sum total content of SiO2, and B-2 O3 and/or aluminum 2O3 - - desirable — 65-mol % — many — less than [90 mol %] — more — desirable — 70-90-mol % — it is the 70-85-mol range of % still more preferably. moreover, the content of SiO2 — desirable — 40-75-mol % — more — desirable — 50-70-mol % — it is — the content of aluminum 2O3 — desirable — 0-25-mol % — more — desirable — 1-20-mol % — it is 2-15-mol % still more preferably. the content of B-2 O3 — desirable — 0-25-mol % — more — desirable — 1-25-mol % — it is 2-20-mol % still more preferably. said content of RO — desirable — less than [15 mol %] — it is less than [12 mol %] more preferably. moreover, the content of MgO — desirable — less than [15 mol %] — more — desirable — less than [12 mol %] — it is — the content of CaO — desirable — less than [10 mol %] — it is less than [8 mol %] more preferably. the content of ZnO — desirable — less than [10 mol %] — more — desirable — less than [8 mol %] — it is — the content of SrO - - desirable — less than [10 mol %] — it is less than [8 mol %] more preferably. the content of BaO — desirable — less than [10 mol %] — it is less than [5 mol %] more preferably. As this RO, MgO is desirable.
[0027] the content of R'2O — desirable — less than [25 mol %] — it is 10-25-mol % more preferably. moreover, the content of Li2O — desirable — less than [20 mol %] — more — desirable — less than [18 mol %] — further — desirable — 5-15-mol % — it is — the content of Na2O — desirable — less than [20 mol %] — more — desirable — less than [15 mol %] — it is 1-10-mol % still more preferably. the content of K2O — desirable — less than [15 mol %] — more — desirable — less than [10 mol %] — it is 0-8-mol % still more preferably. moreover, SiO2 and B-2s O3 and aluminum2 — the sum total content of O3, RO, and R'2O — desirable — more than 85 mol % — more — desirable — more than 90 mol % — it is more than 95 mol % still more preferably.
[0028] furthermore, the content of TiO2 — desirable — 0-7-mol % — more — desirable — 0-5-mol % — it is - - the content of ZrO2 — desirable — 0-8-mol % — it is 0-6-mol % more preferably. moreover, SiO2 and B-2s O3 and aluminum2 — the sum total content of O3, RO, R'2O, and TiO2 and ZrO2 — desirable — more than 95 mol % — it is more than 98 mol % more preferably. Furthermore, the mole ratio (B-2s O3/aluminum 2O3) of B-2s aluminum [O3 and] 2O3 has the desirable range of 0.5-1.5, and it is the range of 0.8-1.2 more preferably.
[0029] As a combination of the above component, it is mol%, for example and is SiO2. 40 - 75%, B-2O3 1-20% (however, the sum total content of SiO2 and B-2s aluminum [O3 and] 2O3 exceeds 65%.) 1 - 25%, aluminum 2O3 MgO 0-10% (however, the sum total content of MgO, CaO and ZnO, and SrO and BaO is less than 20%.) 0 - 15%, ZnO 0 - 10%, CaO 0 - 10%, SrO 0 - 10%, BaO Li2O 0 - 20%, Na2O 0 - 20%, K2O 0 - 15% (However, the sum total content of Li2O, Na2O, and K2O is less than 28%.) TiO2 0 - 10%, and ZrO2 glass ****** whose sum total content of the above-mentioned component is 95% or more, including 0 - 10% — things are made.
[0030] SiO2 is a principal component which forms the network structure of glass, less than [40 mol %], the endurance of glass gets worse and glass becomes easy to devitrify the content. On the other hand, if 75-mol % is exceeded, elevated-temperature viscosity will become high and glass will stop being able to melt easily. Therefore, the content of SiO2 has the desirable 40-75-mol range of %, and its the 50-70-mol range of % is especially desirable.
[0031] B-2 O3 is the important component of this invention. If B-2 O3 is introduced instead of SiO2, when the brittleness of glass will fall sharply and will become low [specific gravity], elevated-temperature viscosity also falls and the solubility of glass is improved greatly. However, when the amount of installation increases exceeding 25-mol %, the endurance of glass gets worse, and since it becomes easy to carry out phase splitting, there is a case where it becomes impossible to make good glass. On the other hand, since brittleness gets worse [the amount of installation] less than [1 mol %] and elevated-temperature viscosity also becomes high, there is a possibility that fertilization of low cost may become impossible. Therefore, 1-25-mol% of the content of B-2 O3 is desirable, and its the 2-20-mol range of % is especially desirable.
[0032] aluminum 2O3 is very important also as a component which raises whenever [stabilization / of glass structure /, and its rigidity] with SiO2 also as a component which contributes thermal resistance, and endurance and low brittleness to glass. However, if the effectiveness that the content stops the elution of the alkali from glass less than [1 mol %] is small, it is hard to make glass with sufficient endurance and it introduces exceeding 20-mol %, since the elevated-temperature melting nature of glass will get worse, the content has the desirable 1-20-mol range of %, and it is the 2-15-mol range of % more preferably.
[0033] MgO, CaO, ZnO, SrO, and BaO are the components introduced in order to lower the viscosity at the time of the dissolution of glass and to raise melting nature and mass-production nature. Since brittleness becomes [a sum total content] high more than at 20 mol %, there is an inclination for glass to become easy to get damaged and for specific gravity and devitrification temperature to also become high. Both soluble [of glass] and low brittle are taken into consideration. The content of MgO, CaO, ZnO, SrO, and BaO MgO — 0-15-mol % — desirable — 0-12-mol % and ZnO — 0-10-mol % — desirable — 0-8-mol % and CaO — 0-10-mol % — desirable — 0-8-mol % — SrO — 0-10-mol % — desirable — 0-8-mol % and BaO — 0-10-mol % — desirable — the 0-5-mol range of % — it is — those sum total contents — desirable — less than [20 mol %] — it is less than [15 mol %] more preferably.
[0034] Li2O, Na2O, and K2O are a very useful component which makes brittleness of glass low while they lower the viscosity at the time of the dissolution of glass and promote the dissolution. However, since chemical

durability not only gets worse, but there is a possibility of eating a magnetic film away in order for alkali to deposit on a glass front face mostly when the amount of installation becomes 28% or more Li2O the content of Li2O, Na2O, and K2O 0-20-mol %, desirable — 0-18-mol % and 2O0-20 mol [of Na] % — desirable — 0-15-mol %, and K 2O0-15-mol % — while considering as 0-10-mol % preferably — those sum total contents — desirable — less than [28 mol %] — it holds down to less than [25 mol %] more preferably.
[0035] the sum total content of SiO2 and B-2s aluminum [O3 and] 2O3 — desirable — 70-90-mol % — more — desirable — the 80-90-mol range of % — it is — the sum total content of RO and R'2O — desirable — 5-35-mol % — more — desirable — 10-30-mol % — further — desirable — 10-25-mol % — it is 10-22-mol % especially preferably.
[0036] ZrO2 and TiO2 are components introduced in order to raise the chemical durability of glass and to raise whenever [rigid]. If ZrO2 and TiO2 are added on glass, the endurance of glass, an elastic modulus, and brittleness will be improved, but specific gravity increases rapidly, and if it introduces more mostly, the devitrification inclination of glass will become strong. [little] therefore, the content of ZrO2 and TiO2 — respectively — 0-10-mol % — desirable — 0-7-mol % and 0-10-mol % — it is preferably restricted to 0-8-mol%. Moreover, the sum total content of the above-mentioned component is more than 95 mol %.
[0037] Since the solubility of glass, clarity, a moldability, etc. are improved on this glass in addition to the above-mentioned component, on it, it is possible to introduce As 2O3, Sb2O3, and F, Cl and SO3 into less than [2 mol %] in total. Moreover, since the endurance and the elastic modulus of glass are raised, other oxides, such as rare earth metal oxides, such as Y2O3 and La2O3, can be added at a rate not more than 5 mol %.
[0038] Furthermore, it is SiO2 at mol %. 55 - 75%, B-2 O3 0 - 20%, 2O31 - 20% (however, the sum total content of SiO2 and B-2s aluminum [O3 and] 2O3 65% or more) of aluminum, MgO 0 - 15%, ZnO 0 - 10%, CaO 0 - 10%, 0 - 10% of SrO(s), BaO 0 - 10% (however, the sum total content of MgO, CaO and ZnO, and SrO and BaO (the content of RO) 20% or less), Li2O 0 - 20%, Na2O 0 - 20%, K2O 0 - 6% (— however, the sum total content (R'2O content) of Li2O, Na2O, and K2O — less than [28%]) and TiO2 0 - 10%, and ZrO2 The sum total content of the above-mentioned component can also mention 95% or more of glass, including 0 - 10%.
[0039] The glass substrate IV for information record media of this invention is SiO2 at mol %. 40 - 75%, B-2 O3 and/or aluminum 2O3 The sum total content of SiO2, B-2s aluminum [O3 and] 2O3, and R'2O consists of glass which is 90% or more, including 2 - 45%, and R'2O(at least one sort as which R' is chosen from Li, Na, and K) 0 - 40%.
[0040] this glass presentation — setting — the content of SiO2 — 50-70-mol % — desirable — the content of B-2 O3 — desirable — 0-25-mol % — more — desirable — 1-25-mol % — further — desirable — 2-20-mol % — it is — the content of aluminum 2O3 — desirable — 0-25-mol % — more — desirable — 1-20-mol % — it is 2-15-mol % still more preferably. the sum total content of SiO2 and B-2s aluminum [O3 and] 2O3 — desirable — 65-90-mol % — more — desirable — 70-90-mol % — it is 70-85-mol % still more preferably. an R'2O content — desirable — 0-28-mol % (however, 0 is removed when RO is zero-mol %) — more — desirable — less than [25 mol %] — it is 10-25-mol % still more preferably. It is 5-15-mol % still more preferably. the content of Li2O — desirable — less than [20 mol %] — more — desirable — less than [18 mol %] — the content of Na2O desirable — less than [20 mol %] — more — desirable — less than [15 mol %] — further — desirable — 1-10-mol % — it is — the content of K2O — desirable — less than [15 mol %] — more — desirable — less than [10 mol %] — it is 0-8-mol % still more preferably. furthermore, the content of RO — desirable — less than [15 mol %] — it is less than [12 mol %] more preferably. moreover, the content of MgO — desirable — less than [15 mol %] — more — desirable — less than [12 mol %] — it is — the content of CaO — desirable — less than [10 mol %] — it is less than [8 mol %] more preferably. the content of ZnO — desirable — less than [10 mol %] — more — desirable — less than [8 mol %] — it is — the content of SrO — - desirable — less than [10 mol %] — it is less than [8 mol %] more preferably. the content of BaO — desirable — less than [10 mol %] — it is less than [5 mol %] more preferably. Especially as RO, MgO is desirable.
[0041] the sum total content of RO and R'2O — desirable — 5-35-mol % — more — desirable — 10-30-mol % — further — desirable — 10-25-mol % — it is 10-22-mol % especially preferably. Furthermore, TiO2 0-10-mol % can be included and the desirable content of TiO2 is 0-7-mol %. Moreover, ZrO2 0-10-mol % can be included and ZrO2 desirable content is 0-7-mol %.
[0042] This glass substrate IV can make an underwater brittleness index value more preferably 1/2 or less [8 micrometers -] still more preferably 1/2 or less [9 micrometers -] 1/2 or less [10.5 micrometers -] 1/2 or less [12 micrometers -]. Moreover, a dew-point can make more preferably the brittleness index value in an ambient atmosphere -5 degrees C or less still more preferably 1/2 or less [4 micrometers -] 1/2 or less [5 micrometers -] 1/2 or less [6 micrometers -] 1/2 or less [7 micrometers -].
[0043] In glass substrate I-IV for information record media of this invention, 70 or more GPas of 75 or more GPas of Young's modulus can be more preferably set to 85 or more GPas.
[0044] It is desirable to raise the Young's modulus of a glass substrate from from [when carrying out high-speed rotation of the information record medium containing the glass substrate of thin meat and the glass substrate concerned prevents deforming by resonance etc.]. For example, when rotating the diameter of 3.5 inches and the magnetic disk produced using the glass substrate with a thickness of 0.635mm with which Young's modulus consists of glass of 70 or more GPas by 10000rpm, the premature start height of the magnetic disk and the record reproducing head concerned can be secured to stability in general by 1 micrometer or less.

[0045] moreover, in a glass substrate with an underwater low brittleness index value, when Young's modulus is 70 or more GPas further, the destruction at the time of handling the glass substrate in the condition of having wetted the glass substrate wet in the condition of having flooded with polish liquid, by grinding, the crack at the time of grinding, polish liquid, or the penetrant remover is markedly alike, and stops being able to happen easily
[0046] Furthermore, in a glass substrate with the low brittleness index value underwater and/or in a desiccation ambient atmosphere, since a glass substrate cannot bend easily due to rotation or a load when Young's modulus is 70 or more GPas further, the destruction at the time of especially an information record medium carrying out high-speed rotation stops being able to happen further easily at the time of polish processing of a glass substrate and information record-medium use.
[0047] Moreover, in glass substrate I-IV of this invention, 20 or more GPas of 25 or more GPas of rigidity can be more preferably set to 30 or more GPas.
[0048] It is desirable to raise the rigidity of a glass substrate from from [when carrying out high-speed rotation of the information record medium containing the glass substrate of thin meat and the glass substrate concerned prevents deforming by resonance etc.]. For example, when rigidity rotates the diameter of 3.5 inches and the magnetic disk produced using the glass substrate with a thickness of 0.635mm which consists of glass of 20 or more GPas by 10000rpm, the premature start height of the magnetic disk and the record reproducing head concerned can be secured to stability in general by 1 micrometer or less.
[0049] moreover, in a glass substrate with an underwater low brittleness index value, when rigidity is 20 or more GPas further, the destruction at the time of handling the glass substrate in the condition of having wetted the glass substrate wet in the condition of having flooded with polish liquid, by grinding, the crack at the time of grinding, polish liquid, or the penetrant remover is markedly alike, and stops being able to happen easily
[0050] Furthermore, in a glass substrate with the low brittleness index value underwater and/or in a desiccation ambient atmosphere, since a glass substrate cannot bend easily due to rotation or a load when rigidity is 20 or more GPas further, the destruction at the time of especially an information record medium carrying out high-speed rotation stops being able to happen further easily at the time of polish processing of a glass substrate and information record-medium use.
[0051] Moreover, in glass substrate I-IV of this invention, a specific Young's modulus (value which **(ed) Young's modulus by the consistency) is 27x106 or more N-m/kg. This specific Young's modulus can set the deflection at the time of high-speed rotation of an information record medium to 2 micrometers or less, and can secure and carry out the thing of the premature start height to stability in 1 micrometer or less as that result at 27x106 or more N-m/kg. Moreover, in a glass substrate with a small brittleness index value, destruction stops being able to happen further easily due to there being few deflections at the time of high-speed rotation. As for this specific Young's modulus, it is more desirable that they are 30x106 or more N-m/kg.
[0052] Moreover, in glass substrate I-IV of this invention, a consistency can also be preferably made into three or less 2.50 g/cm three or less 2.65 g/cm. Furthermore, in glass substrate I-IV of this invention, they are 1/2 or more 0.83 MPa/m more preferably 1/2 or more 0.80 MPa/m 1/2 or more 0.75 MPa/m about a fracture toughness value. The destruction [be / fracture toughness values / 1/2 or more 0.75 MPa/m] at the time of glass substrate processing and use of an information record medium stops being able to happen easily.
[0053] In glass substrate I-IV for information record media of this invention, what viscosity becomes from the glass which has the field which is 1 or more Pa-s is desirable in the temperature field beyond liquid phase temperature.
[0054] In order to obtain the glass substrate for information record media, it is necessary to make it not devitrify substantially by the production process, and to perform the dissolution of a raw material and supply to the die of dissolved glass at least for that purpose above liquid phase temperature. For this reason, it is desirable to make liquid phase temperature of ingredient glass into 1350 degrees C or less in glass substrate I-IV of this invention, it is more desirable that it is 1250 degrees C or less, and it is desirable that it is especially 1150 degrees C or less.
[0055] Here, it becomes difficult to obtain the flat glass substrate for information record media with thin meat by about [that control of the flow rate of melting glass becomes it difficult that the viscosity at the time of supplying melting glass to a die is less than 1 Pa-s] and press forming. In addition, as for glass substrate I-IV of this invention, what consists of glass which has the field whose viscosity is 3 or more Pa-s in the temperature field beyond liquid phase temperature is more desirable.
[0056] The transition point of ingredient glass can be made into 470-640 degrees C in glass substrate I-IV of this invention. If a glass transition point is too high, the temperature field which can carry out press forming will become narrow, it is hard coming to carry out press forming of the glass substrate of thin meat, and after [which will, on the other hand, form magnetic films such as a record layer, in a glass substrate if a glass transition point is too low] forming in the case, the range of the heat-treatment temperature performed for the purpose, such as improvement in magnetic properties, becomes narrow. The range of the desirable transition point is 470-620 degrees C.
[0057] In glass substrate I-IV for information record media of this invention, what a coefficient of thermal expansion becomes from the glass which is more than 60x10-7/degree C in the temperature of 100-300 degrees C is desirable. In case information is recorded on information record media, such as a magnetic disk, an optical disk, and a magneto-optic disk, or in case the information currently recorded on the information record medium concerned is reproduced, the information record medium concerned rotates, after having been fixed to

the spindle of the drive motor prepared in the information processor by the clamp, but if the coefficient of thermal expansion of an information record medium differs from the coefficient of thermal expansion of the aforementioned clamp remarkably in this case, the following problems will arise.

[0058] Namely, although temperature, such as an information record medium, a spindle, and a clamp, carries out a temperature up rapidly to about 90 degrees C by generation of heat of a drive motor etc. in case an information record medium is rotated If the coefficient of thermal expansion of an information record medium differs from the coefficient of thermal expansion of the aforementioned clamp remarkably Slack arises between an information record medium and a clamp according to the aforementioned temperature up, or distortion and bending arise in an information record medium, and the location of the data-logging part (truck) in an information record medium changes as the result, and it becomes easy to produce an error in informational record or playback. Such a problem turns into a problem with a big substrate like 3.5 inches especially.

[0059] Therefore, as for the coefficient of thermal expansion of glass substrate I-IV of this invention, it is desirable to resemble the coefficient of thermal expansion of the aforementioned clamp as much as possible. since the aforementioned clamp is generally produced with the stainless alloy, the coefficient of thermal expansion in 100-300 degrees C of glass substrate I-IV of this invention is more than 60x10-7/degree C — desirable — more — desirable — more than 70x10-7/degree C — further — desirable — 70x10-7/degree-C - 120x10-7/degree C — it is 80x10-7/degree-C - 100x10-7/degree C especially preferably.

[0060] Glass substrate I-IV for information record media of this invention may not have the chemical-strengthening layer, by request, may perform well-known chemical-strengthening processing, and may prepare a chemical-strengthening layer. When performing chemical-strengthening processing, it is good to choose the presentation suitable for chemical-strengthening processing from the range of the above-mentioned glass presentation.

[0061] Chemical-strengthening processing can be performed by the ion-exchange method. This ion-exchange method is performed using the fused salt containing Na ion and K ion, and chemically strengthened glass is obtained. Although it is desirable as processing fused salt containing Na ion and K ion to use a sodium nitrate, a potassium nitrate, and its mixed fused salt, it is not limited to a nitrate and a sulfate, a bisulfate, a carbonate, a halogenide, etc. may be used. As mentioned above, since the glass used by this invention has low brittleness quantity fracture toughness and flexural strength also becomes high according to the ion exchange, the obtained chemically strengthened glass has the outstanding destructive resistance.

[0062] As the manufacture approach of the glass substrate for information record media of this invention, there is especially no limit and it can use various kinds of approaches. For example, the raw materials for glass of elevated-temperature scorification, i.e., a predetermined rate, are dissolved in the inside of air, or an inert gas ambient atmosphere, bubbling, stirring, etc. perform homogenizing of glass, it is fabricated by sheet glass with the pressing method, the well-known down draw method, and a well-known float glass process, circular processing and heart omission, inside-and-outside periphery processing, grinding, polish, etc. are given after that, and it considers as the substrate for information record media of desired size and a configuration. In addition, by polish, surface precision can be made into the range of 0.1-0.6nm by performing polishing processing by abrasives, such as lap INGU and cerium oxide, with abrasives or a diamond pellet.

[0063] On glass substrate I-IV for information record media of above-mentioned this invention, the magnetic information record medium of this invention has a magnetic-recording layer at least, and can mention the configuration which prepared the substrate layer, the magnetic-recording layer, the protective layer, and the lubricating layer one by one on said glass substrate as a configuration of this magnetic information record medium, for example.

[0064] Here, as a magnetic-recording layer, a Co-Cr system, a Co-Cr-Pt system, a Co-nickel-Cr system, a Co-nickel-Pt system, a Co-nickel-Cr-Pt system, a Co-Cr-Ta system, etc. can be used, for example. As a substrate layer, nickel layer, a nickel-P layer, Cr layer, etc. can be used, for example, the carbon film etc. can be used as a protective layer, for example, and lubricant, such as a perfluoro polyether system, can be used as a lubricating layer, for example.

[0065]

[Example] Next, although an example explains this invention to a detail further, this invention is not limited at all by these examples.

[0066] In addition, the physical properties of the glass obtained in each example were measured according to the approach shown below.

(1) The sample with a Young's modulus of 20x20x100mm was produced, and after measuring the longitudinal-wave rate (Vl) and transverse-wave rate (Vs) at the time of a 5MHz supersonic wave spreading the inside of the aforementioned sample using a SHINGUA round type acoustic-velocity measuring device (UVM-2 by the ultrasonic industrial company), it asked by the degree type.

Young's modulus =(4G2-3 G-Vl2 and rho)/(G-Vl2andrho)

G=Vs2andrhorho: The consistency of a sample (g/cm3)

[0067] (2) It can ask for rigidity as G at the time of Young's modulus measurement of the rigidity above (1).

(3) After paying the liquid phase temperature sample to the container made from platinum and leaving it for 30 minutes in a gradient temperature furnace, the existence of the crystal in the front face and the interior of a sample was observed using the optical microscope. And the minimum temperature in which a crystal does not deposit was made into liquid phase temperature.

(4) A glass transition point (Tg), a surrendering point (Td)
About the 5mm phix20mm sample, it measured using the Rigaku apparatus for thermomechanical analysis (TMA8140) with +4-degree-C programming rate for /. In addition, SiO2 was used as a standard sample.
[0068] (5) The average coefficient of thermal expansion in the coefficient of thermal expansion of 100-300 degrees C was meant, and it measured together at the time of measurement of a glass transition point.
(6) it was shown all over Table 1 - 15 to the sample which processed tabular [of 2mm thickness] using the micro hardness tester (MVK-E) of a brittleness index value Akashi factory -- it pushed in, the Vickers indenter was pushed in by the load, and the indentation and the crack were introduced into the sample.
[0069] When making it a value from which a probability becomes 60 or more measures an exact brittleness index value, Vickers hardness, fracture toughness, etc., it is desirable, and a pushing load has a more desirable value which becomes 70 or more, and is desirable to high-priced [which become 80 or more]. When the diagonal line length a and the Vickers indenter of the measured Vickers indentation were pushed in, die-length C of the crack generated from the corner of the Vickers indentation produced on a sample front face was measured. From the above measured value, Vickers hardness Hv, fracture toughness Kc, and the brittleness index value B were calculated using said formula (1) - (3).
[0070] In addition, in order to search for the underwater brittleness index value B, Vickers hardness Hv, fracture toughness Kc, etc., pure waterdrop is dropped on a sample front face, after 30 seconds, the Vickers indenter is stuffed into a sample from on the waterdrop, and an indentation and a crack are introduced.
[0071] Moreover, in order for a dew-point to search for the brittleness index value B in an ambient atmosphere -5 degrees C or less, Vickers hardness Hv, fracture toughness Kc, etc., under desiccation nitrogen-gas-atmosphere mind, checking that the dew-point of the sample circumference is -5 degrees C or less, the Vickers indenter is stuffed into a sample and an indentation and a crack are introduced. In addition, the probability in Table 1 - 14 is the probability of occurrence per each top-most vertices of the crack produced from each four top-most vertices of an indentation.
[0072] It is a start raw material so that the glass of the presentation shown in one to example 81 Table 1 - 14 may be obtained. SiO2, aluminum 2O3, aluminum(OH)3, B-2s O3, HBO3, and MgO, Mg (OH)2, MgCO3, CaCO3, SrCO3, BaCO3, ZnO, 300-1500g weighing capacity was carried out using Li2CO3, Na2CO3, K2CO3, TiO2, ZrO2, etc., and it fully mixed, and accomplished with the preparation batch, this was put into platinum crucible, and glass was dissolved at the temperature of 1400-1600 degrees C for about 3 to 8 hours in air. After melting, after cooling glass melt radiationally to the transition point temperature of a sink and glass to 40x40x20mm carbon metal mold, putting into the annealing furnace immediately and holding for 1 hour, it cooled radiationally to the room temperature in the furnace. A crystal to the extent that the obtained glass is observable under a microscope did not deposit. Thus, the obtained glass was processed, the sample for each physical-properties evaluation was produced, and physical-properties evaluation was performed. The result is shown in Table 1 - 14.
[0073]
[Table 1]

表 1

		実施例					
		1	2	3	4	5	6
組成（モル%）	SiO2	0.0	10.0	20.0	30.0	40.0	45.0
	B2O3	60.0	50.0	40.0	30.0	20.0	10.0
	Al2O3	12.0	12.0	12.0	12.0	12.0	15.0
	MgO	8.0	8.0	8.0	8.0	8.0	10.0
	CaO	15.0	20.0	20.0	15.0	10.0	10.0
	ZnO	—	—	—	—	—	—
	RO	23.0	28.0	28.0	23.0	18.0	20.0
	Li2O	—	—	—	—	—	5.0
	Na2O	—	—	—	0.0	5.0	5.0
	K2O	5.0	0.0	0.0	5.0	5.0	0.0
	R'2O	5.0	0.0	0.0	5.0	10.0	10.0
	TiO2	—	—	—	—	—	—
	ZrO2	—	—	—	—	—	—
	SiO2+B2O3+Al2O3	72.0	72.0	72.0	72.0	72.0	70.0
	B2O3/Al2O3	5.0	4.2	3.3	2.5	1.7	0.7
	RO+R'2O	28.0	28.0	28.0	28.0	28.0	30.0
	SiO2+B2O3+Al2O3+RO+R'2O	100.0	100.0	100.0	100.0	100.0	100.0
	SiO2+B2O3+Al2O3+R'2O	77.0	72.0	72.0	77.0	82.0	80.0
	SiO2+B2O3+Al2O3+RO+R'2O+TiO2+ZrO2	100.0	100.0	100.0	100.0	100.0	100.0
	合計	100.0	100.0	100.0	100.0	100.0	100.0
ガラス転移点 Tg[℃]		552	612	622	590	565	554
屈伏点 Td [℃]		598	660	664	643	620	609
熱膨張係数 $\alpha \times 10^{-7}$[/℃]		67	58	59	66	79	67
密度 [g/cm³]		2.373	2.490	2.522	2.472	2.478	2.547
ヤング率 E[GPa]		65.28	80	81.4	75.52	72.71	87.97
剛性率 G [GPa]		25.56	—	—	30.21	29.30	35.19
水中	押し込み荷重 [gF]	1000	1000	1000	1000	1000	1000
	脆さ指標値 B [$\mu m^{-1/2}$]	11.0	9.4	10.6	7.7	8.2	9.8
	ビッカース硬度 Hv [GPa]	4.6	5.3	5.8	5.3	5.2	6.1
	破壊靭性 Kc [MPa/$m^{1/2}$]	0.46	0.61	0.66	0.73	0.68	0.64
	プロバビリティ	100	100	100	100	100	100
乾燥雰囲気 N2	押し込み荷重 [gF]	1000	1000	1000	1000	1000	1000
	脆さ保存性 B[$\mu m^{-1/2}$]	6.0	5.0	6.1	6.0	5.6	5.9
	ビッカース硬度 Hv [GPa]	—	—	—	5.5	5.1	6.1
	破壊靭性 Kc [MPa/$m^{1/2}$]	—	—	—	0.93	0.98	1.08
	プロバビリティ	—	—	—	100	40	100

[0074]
[Table 2]

表 2

		実施例					
		7	8	9	10	11	12
組成（モル%）	SiO2	45.0	50.0	50.0	50.0	50.0	52.4
	B2O3	20.0	10.0	10.0	10.0	20.0	23.8
	Al2O3	10.0	10.0	10.0	12.0	12.0	9.5
	MgO	10.0	10.0	10.0	8.0	8.0	0.0
	CaO	5.0	10.0	10.0	20.0	0.0	0.0
	ZnO	—	—	—	—	—	—
	RO	15.0	20.0	20.0	28.0	8.0	0.0
	Li2O	0.0	0.0	5.0	—	0.0	0.0
	Na2O	5.0	5.0	5.0	—	5.0	4.8
	K2O	5.0	5.0	0.0	0.0	5.0	9.5
	R'2O	10.0	10.0	10.0	0.0	10.0	14.3
	TiO2	—	—	—	—	—	—
	ZrO2	—	—	—	—	—	—
	SiO2+B2O3+Al2O3	75.0	70.0	70.0	72.0	82.0	85.7
	B2O3/Al2O3	2.0	1.0	1.0	0.8	1.7	2.5
	RO+R'2O	25.0	30.0	30.0	28.0	18.0	14.3
	SiO2+B2O3+Al2O3+RO+R'2O	100.0	100.0	100.0	100.0	100.0	100.0
	SiO2+B2O3+Al2O3+R'2O	85.0	80.0	80.0	72.0	92.0	100.0
	SiO2+B2O3+Al2O3+RO+R'2O+TiO2+ZrO2	100.0	100.0	100.0	100.0	100.0	100.0
	合 計	100.0	100.0	100.0	100.0	100.0	100.0
ガラス転移点 Tg[℃]		548	595	541	576	543	478
屈伏点 Td [℃]		625	676	596	733	614	551
熱膨張係数 $\alpha \times 10^{-7}$[/℃]		77	87	71	52	70	82
密度 [g/cm³]		2.424	2.518	2.540	2.598	2.336	2.292
ヤング率 E[GPa]		68.82	76.62	88.53	86.1	61.54	53.42
剛性率G [GPa]		27.79	31.13	35.74	—	24.84	21.63
水中	押し込み荷重 [gF]	1000	1000	1000	1000	1000	1000
	脆さ指標値 B [$\mu m^{-1/2}$]	6.9	9.3	9.7	9.6	5.7	6.6
	ビッカース硬度 Hv [GPa]	5.1	5.5	5.7	5.9	4.5	4.2
	破壊靭性 Kc [MPa/$m^{1/2}$]	0.76	0.61	0.63	0.64	0.85	0.67
	プロバビリティ	95	100	100	100	95	100
乾燥雰囲気 N2	押し込み荷重 [gF]	5980	1000	1000	1000	6952	5980
	脆さ指標値 B [$\mu m^{-1/2}$]	4.5	5.9	6.1	5.4	3.4	3.4
	ビッカース硬度 Hv [GPa]	4.9	5.5	6.1	5.7	4.4	4.2
	破壊靭性 Kc [MPa/$m^{1/2}$]	1.17	0.96	1.03	1.12	1.40	1.31
	プロバビリティ	80	100	100	85	80	40

[0075]
[Table 3]

表 3

		実施例					
		13	14	16	16	17	18
組成（モル%）	SiO_2	55.0	55.0	55.0	55.0	60.0	60.0
	B_2O_3	10.0	15.0	20.0	25.0	10.0	10.0
	Al_2O_3	12.0	10.0	10.0	10.0	2.5	5.0
	MgO	8.0	10.0	5.0	0.0	10.0	10.0
	CaO	5.0	0.0	0.0	0.0	0.0	0.0
	ZnO	—	—	—	—	0.0	0.0
	RO	13.0	10.0	5.0	0.0	10.0	10.0
	Li_2O	0.0	0.0	0.0	0.0	0.0	0.0
	Na_2O	5.0	5.0	5.0	5.0	12.5	10.0
	K_2O	5.0	5.0	5.0	5.0	5.0	5.0
	R'_2O	10.0	10.0	10.0	10.0	17.5	15.0
	TiO_2	—	—	—	—	0.0	0.0
	ZrO_2	—	—	—	—	—	—
	$SiO_2+B_2O_3+Al_2O_3$	77.0	80.0	85.0	90.0	72.5	75.0
	B_2O_3/Al_2O_3	0.8	1.5	2.0	2.5	4.0	2.0
	$RO+R'_2O$	23.0	20.0	15.0	10.0	27.5	25.0
	$SiO_2+B_2O_3+Al_2O_3+RO+R'_2O$	100.0	100.0	100.0	100.0	100.0	100.0
	$SiO_2+B_2O_3+Al_2O_3+R'_2O$	87.0	90.0	95.0	100.0	90.0	90.0
	$SiO_2+B_2O_3+Al_2O_3+RO+R'_2O+TiO_2+ZrO_2$	100.0	100.0	100.0	100.0	100.0	100.0
	合計	100.0	100.0	100.0	100.0	100.0	100.0
ガラス転移点 Tg[℃]		606	568	522	472	536	541
屈伏点 Td [℃]		678	659	612	558	595	606
熱膨張係数 $\alpha \times 10^{-7}$[/℃]		70	73	66	71	99	87
密度 [g/cm³]		2.439	2.385	2.307	2.238	2.470	2.442
ヤング率 E[GPa]		72.07	65.21	58.72	49.65	73.94	72.54
剛性率G [GPa]		29.43	26.60	23.83	20.02	30.32	29.74
水中	押し込み荷重 [gF]	1000	1000	1000	1000	1000	1000
	脆さ指標値 B [$\mu m^{-1/2}$]	6.7	6.9	5.8	5.4	9.7	6.3
	ビッカース硬度 Hv [GPa]	5.0	4.8	4.4	3.9	5.1	5.1
	破壊靭性 Kc [MPa/$m^{1/2}$]	0.80	0.86	0.81	0.78	0.56	0.87
	プロバビリティ	95	100	100	100	100	100
乾燥雰囲気 N2	押し込み荷重 [gF]	6952	5980	5980	5980	5980	5980
	脆さ指標値 B [$\mu m^{-1/2}$]	4.4	3.6	3.6	3.1	4.9	4.4
	ビッカース硬度 Hv [GPa]	5.0	4.7	4.4	3.9	5.2	5.3
	破壊靭性 Kc [MPa/$m^{1/2}$]	1.24	1.41	1.33	1.36	1.12	1.23
	プロバビリティ	100	100	100	60	100	80

[0076]
[Table 4]

表 4

		実施例					
		19	20	21	22	23	24
組成（モル%）	SiO2	60.0	60.0	60.0	60.0	60.0	60.0
	B2O3	10.0	10.0	10.0	10.0	10.0	10.0
	Al2O3	7.5	10.0	10.0	10.0	10.0	12.0
	MgO	10.0	5.0	10.0	5.0	7.5	8.0
	CaO	0.0	5.0	0.0	0.0	0.0	0.0
	ZnO	0.0	—	—	5.0	0.0	—
	RO	10.0	10.0	10.0	10.0	7.5	8.0
	Li2O	0.0	0.0	0.0	0.0	0.0	0.0
	Na2O	7.5	5.0	5.0	5.0	5.0	5.0
	K2O	5.0	5.0	5.0	5.0	5.0	5.0
	R'2O	12.5	10.0	10.0	10.0	10.0	10.0
	TiO2	0.0	—	—	0.0	2.5	—
	ZrO2	0.0	—	—	0.0	0.0	—
	SiO2+B2O3+Al2O3	77.5	80.0	80.0	80.0	80.0	82.0
	B2O3/Al2O3	1.3	1.0	1.0	1.0	1.0	0.8
	RO+R'2O	22.5	20.0	20.0	20.0	17.5	18.0
	SiO2+B2O3+Al2O3+RO+R'2O	100.0	100.0	100.0	100.0	97.5	100.0
	SiO2+B2O3+Al2O3+R'2O	90.0	90.0	90.0	90.0	90.0	92.0
	SiO2+B2O3+Al2O3+RO +R'2O+TiO2+ZrO2	100.0	100.0	100.0	100.0	100.0	100.0
	合 計	100.0	100.0	100.0	100.0	100.0	100.0
ガラス転移点 Tg[℃]		554	595	583	567	566	598
屈伏点 Td [℃]		619	676	686	672	672	686
熱膨張係数 $\alpha \times 10^{-7}$[/℃]		85	73	77	72	77	66
密度 [g/cm³]		2.409	2.419	2.382	2.448	2.386	2.347
ヤング率 E[GPa]		69.70	70.63	67.26	66.36	66.05	62.00
剛性率G [GPa]		28.54	29.05	27.61	27.17	27.09	—
水中	押し込み荷重 [gF]	1000	1000	1000	1000	1000	1000
	脆さ指標値 B [$\mu m^{-1/2}$]	6.5	6.5	6.1	5.9	5.4	6.0
	ビッカース硬度 Hv [GPa]	5.0	5.3	5.0	4.9	4.8	5.1
	破壊靭性 Kc [MPa/$m^{1/2}$]	0.82	0.83	0.85	0.87	0.95	0.83
	プロバビリティ	100	100	100	95	100	95
乾燥雰囲気 N2	押し込み荷重 [gF]	5980	5980	5980	5980	5980	5980
	脆さ指標値 B [$\mu m^{-1/2}$]	4.2	4.5	4.0	3.9	3.8	4.9
	ビッカース硬度 Hv [GPa]	5.0	5.2	5.0	4.9	4.8	4.9
	破壊靭性 Kc [MPa/$m^{1/2}$]	1.27	1.19	1.29	1.32	1.34	1.01
	プロバビリティ	60	100	100	100	80	100

[0077]
[Table 5]

表 5

		実施例					
		25	26	27	28	29	30
組成（モル%）	SiO2	60.0	60.0	65.0	65.0	65.0	65.0
	B2O3	15.0	20.0	0.0	5.0	5.0	5.0
	Al2O3	10.0	10.0	7.0	2.5	5.0	5.0
	MgO	5.0	0.0	1.0	10.0	10.0	5.0
	CaO	0.0	0.0	1.0	0.0	0.0	5.0
	ZnO	—	—	0.0	0.0	0.0	0.0
	RO	5.0	0.0	2.0	10.0	10.0	10.0
	Li2O	0.0	0.0	10.0	0.0	0.0	0.0
	Na2O	5.0	5.0	10.5	12.5	10.0	10.0
	K2O	5.0	5.0	2.5	5.0	5.0	5.0
	R'2O	10.0	10.0	23.0	17.5	15.0	15.0
	TiO2	—	—	0.0	0.0	0.0	0.0
	ZrO2	—	—	3.0	0.0	—	0.0
	SiO2+B2O3+Al2O3	85.0	90.0	72.0	72.5	75.0	75.0
	B2O3/Al2O3	1.5	2.0	0.0	2.0	1.0	1.0
	RO+R'2O	15.0	10.0	25.0	27.5	25.0	25.0
	SiO2+B2O3+Al2O3+RO+R'2O	100.0	100.0	97.0	100.0	100.0	100.0
	SiO2+B2O3+Al2O3+R'2O	95.0	100.0	95.0	90.0	90.0	90.0
	SiO2+B2O3+Al2O3+RO+R'2O+TiO2+ZrO2	100.0	100.0	100.0	100.0	100.0	100.0
	合 計	100.0	100.0	100.0	100.0	100.0	100.0
ガラス転移点 Tg[℃]		540	488	479	553	558	551
屈伏点 Td [℃]		628	583	551	612.7 626.7	634	619
熱膨張係数 $\alpha \times 10^{-7}$[/℃]		69	71	98	90	85	91
密度[g/cm³]		2.326	2.259	2.535	2.461	2.440	2.483
ヤング率 E[GPa]		81.15	52.00	82.25	73.65	72.10	74.95
剛性率G [GPa]		24.81	—	33.42	30.35	29.73	30.81
水中	押し込み荷重 [gF]	1000	1000	1000	1000	1000	1000
	脆さ指標値 B [$\mu m^{-1/2}$]	6.3	6.2	9.5	7.7	7.6	9.9
	ビッカース硬度 Hv [GPa]	4.8	4.4	—	5.3	5.7	5.4
	破壊靭性 Ko [MPa/$m^{1/2}$]	0.78	0.72	—	0.72	0.73	0.56
	プロバビリティ	100	80	—	100	100	100
乾燥雰囲気 N2	押し込み荷重 [gF]	5980	5980	5980	5980	5980	5980
	脆さ指標値 B [$\mu m^{-1/2}$]	3.8	3.2	5.0	5.8	4.9	5.6
	ビッカース硬度 Hv [GPa]	4.8	4.1	8.0	5.6	5.8	5.4
	破壊靭性 Kc [MPa/$m^{1/2}$]	1.28	1.36	1.18	0.97	1.13	0.99
	プロバビリティ	100	80	100	100	100	100

[0078]
[Table 6]

表 6

		実施例					
		31	32	33	34	35	36
組成（モル%）	SiO2	65.0	65.0	65.0	65.0	65.0	65.0
	B2O3	5.0	5.0	5.0	5.0	5.0	5.0
	Al2O3	5.0	5.0	5.0	5.0	5.0	5.0
	MgO	5.0	5.0	5.0	5.0	5.0	5.0
	CaO	3.0	3.0	5.0	5.0	5.0	5.0
	ZnO	—	—	—	—	—	—
	RO	8.0	8.0	10.0	10.0	10.0	10.0
	Li2O	2.0	0.0	2.0	2.0	2.0	4.0
	Na2O	10.0	12.0	11.0	9.0	7.0	9.0
	K2O	5.0	5.0	2.0	4.0	6.0	2.0
	R'2O	17.0	17.0	15.0	15.0	15.0	15.0
	TiO2	0.0	0.0	0.0	0.0	0.0	0.0
	ZrO2	—	—	—	—	—	—
	SiO2+B2O3+Al2O3	75.0	75.0	75.0	75.0	75.0	75.0
	B2O3/Al2O3	1.0	1.0	1.0	1.0	1.0	1.0
	RO+R'2O	25.0	25.0	25.0	25.0	25.0	25.0
	SiO2+B2O3+Al2O3+RO+R'2O	100.0	100.0	100.0	100.0	100.0	100.0
	SiO2+B2O3+Al2O3+R'2O	92.0	92.0	90.0	90.0	90.0	90.0
	SiO2+B2O3+Al2O3+RO +R'2O+TiO2+ZrO2	100.0	100.0	100.0	100.0	100.0	100.0
	合計	100.0	100.0	100.0	100.0	100.0	100.0
ガラス転移点 Tg[℃]		511	540	524	526	523	507
屈伏点 Td [℃]		581	608	599	593	595	572
熱膨張係数 $\alpha \times 10^{-7}$[/℃]		92	95	83	85	87	106
密度 [g/cm³]		2.473	2.477	2.485	2.482	2.477	2.478
ヤング率 E[GPa]		78.71	74.00	78.97	78.28	77.13	80.71
剛性率G [GPa]		31.62	30.48	32.50	32.21	31.74	33.26
水中	押し込み荷重 [gF]	1000	1000	1000	1000	1000	1000
	脆さ指標値 B [$\mu m^{-1/2}$]	9.9	9.8	9.8	10.0	10.6	10.0
	ビッカース硬度 Hv [GPa]	5.6	5.3	5.7	5.8	5.8	5.8
	破壊靭性 Kc [MPa/$m^{1/2}$]	0.58	0.56	0.60	0.58	0.55	0.59
	プロバビリティ	100	100	100	100	100	100
乾燥雰囲気 N2	押し込み荷重 [gF]	5980	5980	5980	5980	5980	5980
	脆さ指標値 B [$\mu m^{-1/2}$]	5.0	4.8	5.4	5.6	5.5	5.1
	ビッカース硬度 Hv [GPa]	5.6	5.1	5.5	5.7	5.7	5.6
	破壊靭性 Ko [MPa/$m^{1/2}$]	1.13	1.14	1.08	1.04	1.04	1.15
	プロバビリティ	100	100	100	100	100	100

[0079]
[Table 7]

表 7

		実施例					
		37	38	39	40	41	42
組成（モル%）	SiO2	65.0	65.0	65.0	65.0	65.0	65.0
	B2O3	5.0	5.0	5.0	5.0	5.0	5.0
	Al2O3	5.0	5.0	5.0	5.0	5.0	5.0
	MgO	5.0	5.0	5.0	5.0	5.0	5.0
	CaO	5.0	5.0	5.0	5.0	5.0	5.0
	ZnO	—	—	—	—	—	0.0
	RO	10.0	10.0	10.0	10.0	10.0	10.0
	Li2O	4.0	4.0	6.0	6.0	6.0	8.0
	Na2O	7.0	5.0	7.0	5.0	3.0	5.0
	K2O	4.0	6.0	2.0	4.0	6.0	2.0
	R'2O	15.0	15.0	15.0	15.0	15.0	15.0
	TiO2	0.0	0.0	0.0	0.0	0.0	0.0
	ZrO2	—	—	—	—	—	0.0
	SiO2+B2O3+Al2O3	75.0	75.0	75.0	75.0	75.0	75.0
	B2O3/Al2O3	1.0	1.0	1.0	1.0	1.0	1.0
	RO+R'2O	25.0	25.0	25.0	25.0	25.0	25.0
	SiO2+B2O3+Al2O3+RO+R'2O	100.0	100.0	100.0	100.0	100.0	100.0
	SiO2+B2O3+Al2O3+R'2O	90.0	90.0	90.0	90.0	80.0	90.0
	SiO2+B2O3+Al2O3+RO +R'2O+TiO2+ZrO2	100.0	100.0	100.0	100.0	100.0	100.0
	合計	100.0	100.0	100.0	100.0	100.0	100.0
ガラス転移点 Tg[℃]		510	508	500	501	501	488
屈伏点 Td [℃]		579	579	566	568	571	552
熱膨張係数 $\alpha \times 10^{-7}$[/℃]		85	115	78	81	80	78
密度 [g/cm³]		2.474	2.469	2.470	2.465	2.460	2.464
ヤング率 E[GPa]		79.81	78.63	82.37	81.18	79.50	83.61
剛性率G [GPa]		32.88	32.38	33.93	33.44	32.76	34.44
水中	押し込み荷重 [gF]	1000	1000	1000	1000	1000	1000
	脆さ指標値 B [$\mu m^{-1/2}$]	10.1	10.5	10.0	9.9	10.4	9.9
	ビッカース硬度 Hv [GPa]	5.9	5.8	5.9	5.9	5.9	6.1
	破壊靭性 Kc [MPa/$m^{1/2}$]	0.58	0.56	0.60	0.60	0.57	0.61
	プロバビリティ	100	100	100	100	100	100
乾燥雰囲気 N2	押し込み荷重 [gF]	5980	5980	5980	5980	5980	5980
	脆さ指標値 B [$\mu m^{-1/2}$]	5.6	5.1	4.9	5.0	5.2	4.7
	ビッカース硬度 Hv [GPa]	5.7	5.5	5.6	5.6	5.6	5.5
	破壊靭性 Kc [MPa/$m^{1/2}$]	1.04	1.13	1.13	1.17	1.11	1.25
	プロバビリティ	100	100	100	100	100	100

[0080]
[Table 8]

表 8

		実施例					
		43	44	45	46	47	48
組成（モル%）	SiO2	65.0	65.0	65.0	65.0	65.0	65.0
	B2O3	5.0	5.0	5.0	5.0	5.0	5.0
	Al2O3	5.0	5.0	5.0	5.0	5.0	7.0
	MgO	5.0	5.0	5.0	5.0	5.0	5.0
	CaO	5.0	5.0	5.0	0.0	0.0	3.0
	ZnO	0.0	0.0	0.0	0.0	0.0	—
	RO	10.0	10.0	10.0	5.0	5.0	8.0
	Li2O	8.0	8.0	0.0	8.0	2.0	0.0
	Na2O	3.0	1.0	11.0	10.0	10.0	10.0
	K2O	4.0	6.0	4.0	2.0	5.0	5.0
	R'2O	15.0	15.0	15.0	20.0	17.0	15.0
	TiO2	0.0	0.0	0.0	0.0	0.0	0.0
	ZrO2	0.0	—	0.0	0.0	3.0	—
	SiO2+B2O3+Al2O3	75.0	75.0	75.0	75.0	75.0	77.0
	B2O3/Al2O3	1.0	1.0	1.0	1.0	1.0	0.7
	RO+R'2O	25.0	25.0	25.0	25.0	22.0	23.0
	SiO2+B2O3+Al2O3+RO+R'2O	100.0	100.0	100.0	100.0	97.0	100.0
	SiO2+B2O3+Al2O3+R'2O	90.0	90.0	90.0	95.0	92.0	92.0
	SiO2+B2O3+Al2O3+RO+R'2O+TiO2+ZrO2	100.0	100.0	100.0	100.0	100.0	100.0
	合 計	100.0	100.0	100.0	100.0	100.0	100.0
ガラス転移点 Tg[℃]		494	504	552	474	533	536
屈伏点 Td [℃]		561	577	622	536	615	596
熱膨張係数 $\alpha \times 10^{-7}$[/℃]		81	73	89	91	87	122
密度 [g/cm³]		2.458	2.446	2.485	2.449	2.525	2.462
ヤング率 E[GPa]		82.10	79.04	75.27	79.92	77.29	71.94
剛性率G [GPa]		33.82	32.64	30.96	32.45	31.61	29.58
水中	押し込み荷重 [gF]	1000	1000	1000	1000	1000	1000
	脆さ指標値 B [$\mu m^{-1/2}$]	9.8	9.9	9.9	9.5	9.0	8.5
	ビッカース硬度 Hv [GPa]	5.9	5.7	5.8	—	—	5.1
	破壊靭性 Kc [MPa/$m^{1/2}$]	0.61	0.59	0.58	—	—	0.63
	プロバビリティ	100	100	100	—	—	100
乾燥雰囲気 N2	押し込み荷重 [gF]	5980	5980	5980	5980	5980	5980
	脆さ指標値 B [$\mu m^{-1/2}$]	4.7	4.8	5.7	4.6	4.3	5.1
	ビッカース硬度 Hv [GPa]	5.6	5.4	5.5	5.6	5.5	5.2
	破壊靭性 Kc [MPa/$m^{1/2}$]	1.25	1.19	0.99	1.27	1.30	1.06
	プロバビリティ	100	100	100	100	100	100

[0081]
[Table 9]

表 9

		実施例						
		49	50	51	52	53	54	55
組成（モル%）	SiO2	65.0	65.0	65.0	65.0	65.4	65.4	65.4
	B2O3	5.0	5.0	7.5	10.0	0.0	0.0	0.0
	Al2O3	7.5	10.0	2.5	0.0	8.6	8.6	8.6
	MgO	10.0	10.0	5.0	5.0	0.0	0.0	0.0
	CaO	0.0	0.0	5.0	5.0	0.0	0.0	0.0
	ZnO	0.0	0.0	—	—	0.0	0.0	0.0
	RO	10.0	10.0	10.0	10.0	0.0	0.0	0.0
	Li2O	0.0	0.0	0.0	0.0	12.5	7.5	0.0
	Na2O	7.5	5.0	10.0	10.0	10.5	10.5	13.0
	K2O	5.0	5.0	5.0	5.0	0.0	5.0	10.0
	R'2O	12.5	10.0	15.0	15.0	23.0	23.0	23.0
	TiO2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	ZrO2	—	—	—	—	3.0	3.0	3.0
	SiO2+B2O3+Al2O3	77.5	80.0	75.0	75.0	74.0	74.0	74.0
	B2O3/Al2O3	0.7	0.5	3.0	—	0.0	0.0	0.0
	RO+R'2O	22.5	20.0	25.0	25.0	23.0	23.0	23.0
	SiO2+B2O3+Al2O3+RO+R'2O	100.0	100.0	100.0	100.0	97.0	97.0	97.0
	SiO2+B2O3+Al2O3+R'2O	90.0	90.0	90.0	90.0	97.0	97.0	97.0
	SiO2+B2O3+Al2O3+RO +R'2O+TiO2+ZrO2	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	合 計	100.0	100.0	100.0	100.0	100.0	100.0	100.0
ガラス転移点 Tg[℃]		577	631	557	559	498	491	534
屈伏点 Td [℃]		658	752	622	623	564	568	629
熱膨張係数 $\alpha \times 10^{-7}$[/℃]		76	70	87	89	89	116	113
密度 [g/cm³]		2.419	2.399	2.486	2.493	2.511	2.523	2.537
ヤング率 E[GPa]		71.46	70.77	76.10	78.41	84.13	79.70	71.31
剛性率 G [GPa]		29.51	29.49	31.35	32.37	34.71	32.82	29.30
水中	押し込み荷重 [gF]	1000	1000	1000	1000	1000	1000	1000
	脆さ指標値 B [$\mu m^{-1/2}$]	8.4	7.1	10.4	13.2	7.8	8.4	7.9
	ビッカース硬度 Hv [GPa]	5.6	5.1	5.4	5.9	5.6	5.7	5.4
	破壊靭性 Kc [MPa/$m^{1/2}$]	0.96	0.76	0.54	0.44	0.77	0.70	0.69
	プロバビリティ	100	100	100	100	100	100	100
乾燥雰囲気 N2	押し込み荷重 [gF]	5980	5980	5980	5980	5980	5980	5980
	脆さ保存性 B[$\mu m^{-1/2}$]	5.2	5.3	4.9	5.5	4.3	5.0	5.2
	ビッカース硬度 Hv [GPa]	5.6	5.2	5.2	5.5	5.4	5.5	4.9
	破壊靭性 Kc [MPa/$m^{1/2}$]	1.05	1.01	1.13	1.05	1.37	1.16	1.02
	プロバビリティ	100	100	100	100	100	100	100

[0082]
[Table 10]

表 10

		実施例					
		56	57	58	59	60	61
組成（モル%）	SiO2	48.0	53.2	57.0	59.0	59.0	59.0
	B2O3	16.0	14.4	9.5	9.0	9.5	10.5
	Al2O3	16.0	14.4	9.5	9.0	9.5	10.5
	MgO	0.0	0.0	2.0	3.0	2.0	0.0
	CaO	0.0	0.0	0.0	0.0	0.0	0.0
	ZnO	0.0	0.0	0.0	0.0	0.0	0.0
	RO	0.0	0.0	2.0	3.0	2.0	0.0
	Li2O	10.0	10.0	9.0	10.0	9.0	10.0
	Na2O	8.0	6.0	9.0	10.0	9.0	5.0
	K2O	2.0	2.0	2.0	0.0	2.0	5.0
	R'2O	20.0	18.0	20.0	20.0	20.0	20.0
	TiO2	0.0	0.0	0.0	0.0	0.0	0.0
	ZrO2	0.0	0.0	2.0	0.0	0.0	0.0
	SiO2+B2O3+Al2O3	80.0	82.0	76.0	77.0	78.0	80.0
	B2O3/Al2O3	1.0	1.0	1.0	1.0	1.0	1.0
	RO+R'2O	20.0	18.0	22.0	23.0	22.0	20.0
	SiO2+B2O3+Al2O3+RO+R'2O	100.0	100.0	98.0	100.0	100.0	100.0
	SiO2+B2O3+Al2O3+R'2O	100.0	100.0	96.0	97.0	98.0	100.0
	SiO2+B2O3+Al2O3+RO +R'2O+TiO2+ZrO2	100.0	100.0	100.0	100.0	100.0	100.0
	合 計	100.0	100.0	100.0	100.0	100.0	100.0
ガラス転移点 Tg[℃]		475	483	484	483	476	473
屈伏点 Td [℃]		525	539	543	534	530	529
熱膨張係数 $\alpha \times 10^{-7}$[/℃]		90	77	89	84	87	84
密度 [g/cm³]		2.382	2.359	2.492	2.456	2.444	2.415
ヤング率 E[GPa]		72.62	71.84	81.35	83.13	80.45	77.88
剛性率 G [GPa]		28.16	28.96	32.96	33.70	32.73	31.71
乾燥雰囲気 N2	押し込み荷重 [gF]	6952	6952	6952	6952	6952	6952
	脆さ保存性 B[$\mu m^{-1/2}$]	3.5	3.1	3.9	3.8	3.7	3.8
	ビッカース硬度 Hv [GPa]	5.2	5.0	5.8	5.8	5.7	5.5
	破壊靭性 Kc [MPa/$m^{1/2}$]	1.54	1.71	1.59	1.57	1.56	1.51
	プロバビリティ	20	60	100	100	100	80

[0083]
[Table 11]

表 11

		実施例					
		62	63	64	65	66	67
組成（モル%）	SiO2	59.0	60.0	60.0	60.0	60.0	61.0
	B2O3	10.5	0.0	5.0	7.5	9.0	5.0
	Al2O3	10.5	15.0	15.0	7.5	9.0	12.0
	MgO	0.0	5.0	0.0	5.0	0.0	5.0
	CaO	0.0	0.0	0.0	0.0	0.0	0.0
	ZnO	0.0	0.0	0.0	0.0	0.0	0.0
	RO	0.0	5.0	0.0	5.0	0.0	5.0
	Li2O	10.0	9.0	9.0	10.0	9.0	10.0
	Na2O	10.0	9.0	9.0	5.0	9.0	5.0
	K2O	0.0	2.0	2.0	5.0	2.0	2.0
	R'2O	20.0	20.0	20.0	20.0	20.0	17.0
	TiO2	0.0	0.0	0.0	0.0	0.0	0.0
	ZrO2	0.0	0.0	0.0	0.0	2.0	0.0
	SiO2+B2O3+Al2O3	80.0	75.0	80.0	75.0	78.0	78.0
	B2O3/Al2O3	1.0	0.0	0.3	1.0	1.0	0.4
	RO+R'2O	20.0	25.0	20.0	25.0	20.0	22.0
	SiO2+B2O3+Al2O3+RO+R'2O	100.0	100.0	100.0	100.0	98.0	100.0
	SiO2+B2O3+Al2O3+R'2O	100.0	95.0	100.0	95.0	98.0	95.0
	SiO2+B2O3+Al2O3+RO +R'2O+TiO2+ZrO2	100.0	100.0	100.0	100.0	100.0	100.0
	合 計	100.0	100.0	100.0	100.0	100.0	100.0
ガラス転移点 Tg[℃]		485	530	491	464	487	495
屈伏点 Td [℃]		536	610	560	535	545	564
熱膨張係数 $\alpha \times 10^{-7}$[/℃]		82	93	88	91	87	78
密度 [g/cm³]		2.420	2.464	2.428	2.428	2.48	2.422
ヤング率 E[GPa]		80.13	82.79	78.75	79.23	81.53	80.56
剛性率 G [GPa]		32.65	33.71	32.05	32.38	33.22	32.77
乾燥雰囲気 N2	押し込み荷重 [gF]	6952	6952	6952	6952	6952	6952
	脆さ保存性 B[$\mu m^{-1/3}$]	3.5	4.2	4.1	4.2	3.9	3.9
	ビッカース硬度 Hv [GPa]	5.5	5.7	5.4	5.8	5.8	5.5
	破壊靭性 Kc [MPa/$m^{1/2}$]	1.65	—	—	1.40	1.50	—
	プロバビリティ	75	80	100	60	80	100

[0084]
[Table 12]

表 12

		実施例					
		68	69	70	71	72	73
組成（モル%）	SiO2	61.0	62.0	63.0	63.0	63.0	65.0
	B2O3	9.5	7.0	7.5	8.5	8.5	2.5
	Al2O3	9.5	7.0	7.5	8.5	8.5	10.5
	MgO	0.0	2.0	2.0	0.0	0.0	5.0
	CaO	0.0	—	0.0	0.0	0.0	0.0
	ZnO	0.0	—	0.0	0.0	0.0	0.0
	RO	0.0	2.0	2.0	0.0	0.0	5.0
	Li2O	10.0	9.0	9.0	10.0	9.0	10.0
	Na2O	10.0	9.0	9.0	10.0	9.0	5.0
	K2O	0.0	2.0	2.0	0.0	2.0	2.0
	R'2O	20.0	20.0	20.0	20.0	20.0	17.0
	TiO2	0.0	—	0.0	0.0	0.0	0.0
	ZrO2	0.0	2.0	0.0	0.0	0.0	0.0
	SiO2+B2O3+Al2O3	80.0	76.0	78.0	80.0	80.0	78.0
	B2O3/Al2O3	1.0	1.0	1.0	1.0	1.0	0.2
	RO+R'2O	20.0	22.0	22.0	20.0	20.0	22.0
	SiO2+B2O3+Al2O3+RO+R'2O	100.0	98.0	100.0	100.0	100.0	100.0
	SiO2+B2O3+Al2O3+R'2O	100.0	96.0	98.0	100.0	100.0	95.0
	SiO2+B2O3+Al2O3+RO +R'2O+TiO2+ZrO2	100.0	100.0	100.0	100.0	100.0	100.0
	合 計	100.0	100.0	100.0	100.0	100.0	100.0
ガラス転移点 Tg[℃]		483	480	471	480	479	493
屈伏点 Td [℃]		535	540	528	533	537	568
熱膨張係数 $\alpha \times 10^{-7}$[/℃]		85	86	89	84	89	80
密度 [g/cm³]		2.427	2.450	2.448	2.431	2.431	2.421
ヤング率 E[GPa]		81.00	83.00	80.96	81.57	79.91	80.67
剛性率 G [GPa]		33.06	—	33.00	33.37	32.71	33.09
乾燥雰囲気 N2	押し込み荷重 [gF]	6952	6952	6952	6952	6952	6952
	脆さ保存性 B[$\mu m^{-1/3}$]	3.7	4.0	4.1	3.9	3.8	4.1
	ビッカース硬度 Hv [GPa]	5.8	—	5.7	5.5	5.5	5.7
	破壊靭性 Kc [MPa/$m^{1/2}$]	1.58	—	1.44	1.51	1.52	—
	プロバビリティ	40	—	100	100	100	100

[0085]
[Table 13]

表 13

		実施例			
		74	75	76	77
組成（モル%）	SiO2	65.0	65.0	65.0	65.0
	B2O3	5.0	7.5	7.5	7.5
	Al2O3	5.0	7.5	7.5	7.5
	MgO	0.0	0.0	0.0	0.0
	CaO	0.0	0.0	0.0	0.0
	ZnO	0.0	0.0	0.0	0.0
	RO	0.0	0.0	0.0	0.0
	Li2O	10.0	5.0	10.0	10.0
	Na2O	10.0	10.0	5.0	7.5
	K2O	5.0	5.0	5.0	2.5
	R'2O	25.0	20.0	20.0	20.0
	TiO2	0.0	0.0	0.0	0.0
	ZrO2	0.0	0.0	0.0	0.0
	SiO2+B2O3+Al2O3	75.0	80.0	80.0	80.0
	B2O3/Al2O3	1.0	1.0	1.0	1.0
	RO+R'2O	25.0	20.0	20.0	20.0
	SiO2+B2O3+Al2O3+RO+R'2O	100.0	100.0	100.0	100.0
	SiO2+B2O3+Al2O3+R'2O	100.0	100.0	100.0	100.0
	SiO2+B2O3+Al2O3+RO +R'2O+TiO2+ZrO2	100.0	100.0	100.0	100.0
	合 計	100.0	100.0	100.0	100.0
ガラス転移点 Tg[℃]		451	482	475	472
屈伏点 Td [℃]		510	541	538	529
熱膨張係数 $\alpha \times 10^{-7}$[/℃]		107	95	85	84
密度 [g/cm³]		2.453	2.452	2.420	2.429
ヤング率 E[GPa]		77.98	77.81	78.83	80.62
剛性率 G [GPa]		31.79	31.87	32.27	33.01
乾燥雰囲気 N2	押し込み荷重 [gF]	6952	6952	6952	6952
	脆さ保存性 B[$\mu m^{-1/3}$]	4.0	4.3	4.1	3.9
	ビッカース硬度 Hv [GPa]	5.4	5.4	5.7	5.6
	破壊靭性 Kc [MPa/$m^{1/2}$]	1.42	1.31	1.42	1.51
	プロバビリティ	100	100	100	80

[0086]
[Table 14]

表 14

		実施例			
		78	79	80	81
組成（モル%）	SiO2	65.0	65.0	65.0	65.0
	B2O3	7.5	7.5	7.5	10.0
	Al2O3	7.5	7.5	7.5	0.0
	MgO	0.0	0.0	0.0	5.0
	CaO	0.0	0.0	0.0	0.0
	ZnO	0.0	0.0	0.0	0.0
	RO	0.0	0.0	0.0	5.0
	Li2O	10.0	10.0	9.0	5.0
	Na2O	10.0	10.0	9.0	10.0
	K2O	0.0	0.0	2.0	5.0
	R'2O	20.0	20.0	20.0	20.0
	TiO2	0.0	0.0	0.0	0.0
	ZrO2	0.0	0.0	0.0	0.0
	SiO2+B2O3+Al2O3	80.0	80.0	80.0	75.0
	B2O3/Al2O3	1.0	1.0	1.0	—
	RO+R'2O	20.0	20.0	20.0	25.0
	SiO2+B2O3+Al2O3+RO+R'2O	100.0	100.0	100.0	100.0
	SiO2+B2O3+Al2O3+R'2O	100.0	100.0	100.0	95.0
	SiO2+B2O3+Al2O3+RO +R'2O+TiO2+ZrO2	100.0	100.0	100.0	100.0
	合 計	100.0	100.0	100.0	100.0
ガラス転移点 Tg[℃]		483	478	477	484
屈伏点 Td [℃]		544	533	533	541
熱膨張係数 $\alpha \times 10^{-7}$[/℃]		83	83	85	98
密度 [g/cm³]		2.440	2.431	2.434	2.477
ヤング率 E[GPa]		82.07	82.00	80.81	80.64
剛性率 G [GPa]		33.58	33.65	33.15	33.02
乾燥雰囲気 N2	押し込み荷重 [gF]	1000	1000	1000	1000
	脆さ保存性 B[$\mu m^{-1/3}$]	3.9	3.8	3.9	4.2
	ビッカース硬度 Hv [GPa]	5.6	5.6	5.7	5.7
	破壊靭性 Kc [MPa/$m^{1/2}$]	1.52	1.53	1.48	1.39
	プロバビリティ	80	100	100	100

[0087] About the glass indicated by the example 1 of a comparison - 3 JP,10-158028,A, the physical properties were shown in Table 15.

[0088]

[Table 15]

表 15

		比較例 1	比較例 2	比較例 3
組成（モル%）	SiO2	69.28	69.94	68.94
	B2O3	—	—	—
	Al2O3	2.5	2.51	4.24
	MgO	6.97	6.96	5.77
	CaO	7.97	8	8.28
	SrO	—	0.24	1.81
	Li2O	—	—	—
	Na2O	1.96	4.93	1.46
	K2O	9.56	6.75	9.25
	TiO2	—	—	—
	ZrO2	1.76	0.66	0.26
	合 計	100.0	100.0	100.0
ガラス転移点 Tg[℃]		657	623	658
屈伏点 Td [℃]		780	710	732
熱膨張係数 $\alpha \times 10^{-7}$[/℃]		86.8	85.8	82.8
密度 [g/cm^3]		2.52	2.49	2.51
ヤング率 E[GPa]		80.5	80.3	81.5
押し込み荷重 [gF]		1000	1000	1000
脆さ指標値 B [$\mu m^{-1/2}$]		7.2	7.2	7.1
ビッカース硬度 Hv [GPa]		6.1	6.1	6.2
破壊靭性 Kc [MPa/m$^{1/2}$]		0.90	0.91	1.05

[0089] The glass obtained in the example 82 examples 1-81 is used, and it is (1) rough wrapping process (rough grinding process), (2) By performing a configuration processing process, (3) energy wrapping process (energy grinding operation), (4) end-face mirror plane processing process, the (5) 1st polish processes, the (6) 2nd polish processes, (7) inspection processes, and (8) magnetic-disk production process one by one, the glass substrate for information record media was produced, and the magnetic disk was manufactured further. In addition, pure water was used for the water of the polish liquid used for the polish equipment from the above-mentioned (4) end-face mirror plane processing process to the (6) 2nd polish processes.

[0090] (1) Rough wrapping ** obtained diameter 96mmphi and a disc-like glass substrate with a thickness of 1.5mm from melting glass with the direct press using a punch, female mold, and a mold more nearly first. In addition, in this case, in addition to a direct press, it may start with a grinding stone from the sheet glass formed with the down draw method or the float glass process, and a disc-like glass substrate may be obtained.

[0091] Subsequently, the wrapping process was performed in order to raise dimensional accuracy and configuration precision to a glass substrate. This wrapping process was performed using the abrasive grain of grain-size #400 using double-sided wrapping equipment. Both sides of the glass substrate contained in the carrier were wrapped at the profile irregularity of 0-1 micrometer, and about 6 micrometers (Rmax) of surface roughness by using the alumina abrasive grain of grain-size #400 first, specifically setting a load as about 980N, and rotating an internal gear with Sun Geer.

[0092] (2) While vacating the hole for the central part of a glass substrate using the grinding stone of the shape of a configuration processing process, next a cylinder, after carrying out grinding of a periphery end face and setting a diameter to 95mmphi, predetermined beveling processing was performed to the periphery end face and the inner circumference end face. The surface roughness of the glass substrate end face in this case was about 4 micrometers in Rmax.

[0093] (3) By changing an energy wrapping process, next the grain size of an abrasive grain into #1000, and wrapping a glass substrate front face, it was set as about 2 micrometers by Rmax, and surface roughness was set to about 0.2 micrometers by Ra. Sequential immersion of the glass substrate which finished the above-mentioned wrapping process was carried out at each washing tub (ultrasonic impression) of neutral detergent and water, and ultrasonic cleaning was performed.

[0094] (4) More nearly subsequently, rotating a glass substrate, by brushing, it ground to 1 micrometer by Rmax, and end-face mirror plane ****** ground the granularity of the front face of the end face (inner circumference, periphery) of a glass substrate to about 0.3 micrometers by Ra. And backwashing by water of the front face of the glass substrate which finished the above-mentioned end-face mirror plane processing was carried out.

[0095] (5) In order to remove the blemish and distortion which remained at the 1st polish process, next the wrapping process mentioned above, the 1st polish process was performed using double-sided polish equipment. In double-sided polish equipment, the glass substrate held with the carrier is stuck between the vertical surface

plates with which the scouring pad was stuck, this carrier is meshed to Sun Geer and an internal gear, and the above-mentioned glass substrate is compressed with a vertical surface plate. Then, by supplying polish liquid between a scouring pad and the polished surface of a glass substrate, and making it rotate, while a glass substrate rotates on a surface plate, it revolves around the sun, and polish processing of both sides is carried out at coincidence. Hereafter, the same equipment was used as double-sided polish equipment used in the example.

[0096] Specifically, the polish process was carried out, using a hard polisher (hard urethane foam) as a polisher. Polish conditions were used as cerium oxide (mean particle diameter of 1.3 micrometers) + pure water as polish liquid, and were made into load:9.8mN/mm2, and polish time amount:15 minutes. To neutral detergent, pure water, pure water, isopropyl alcohol (IPA), and each washing tub of IPA (steam seasoning), sequential immersion was carried out, and the glass substrate which finished the above-mentioned 1st polish process was cleaned ultrasonically, and was dried to them.

[0097] (6) the 2nd polish process — using the double-sided polish equipment same type as what was used at the 1st polish process next, the polisher was changed into the elasticity polisher (suede putt), and the 2nd polish process was carried out. This 2nd polish process aims at reducing surface roughness Ra to about 1.0-0.3 micrometers or less, for example, maintaining the flat front face obtained at the 1st polish process mentioned above. Polish conditions were used as cerium oxide (mean particle diameter of 0.8 micrometers) + pure water as polish liquid, and made load:9.8mN/mm2 and polish time amount 5 minutes. To neutral detergent, pure water, pure water, and each washing tub of IPA and IPA (steam seasoning), sequential immersion was carried out, and the glass substrate which finished the above-mentioned 2nd polish process was cleaned ultrasonically, and was dried to them. Although the glass substrate of this example did not have a chemical-strengthening layer, a glass substrate did not destroy it at the time of handling of the inside of said polish process, a process, and a process.

[0098] (7) The close examination using the visual inspection on an inspection process, next the front face of a glass substrate which finished the above-mentioned desiccation, and reflection, dispersion and transparency of light was carried out. Consequently, defects, such as a blemish, were not discovered on a glass substrate front face. Moreover, when the surface roughness on the front face of main of a glass substrate pass the above-mentioned process was measured with the atomic force microscope (AFM), the glass substrate for magnetic disks with Rmax=2.13nm, Ra=0.20nm, and an overly smooth front face was obtained.

[0099] (8) The inline-type sputtering system was used for both the main front face of the glass substrate for magnetic disks pass the magnetic-disk production process above-mentioned process, sequential membrane formation of a NiAl seed layer, a CrV substrate layer, a CoPtCrB magnetic layer, and the hydrogenation carbon protective layer was carried out, the perfluoro polyether lubricating layer was further formed with the dip method, and the magnetic disk was obtained. About the obtained magnetic disk, when the touch-down height test was carried out, the touch-down height showed 5nm and a good value. Moreover, even if it performed the load unload trial (100,000 times), a head did not crash.

[0100] The magnetic disk was manufactured like the example 82 except having performed the following chemical-strengthening process between the (6) aforementioned 2nd polish processes in example 83 example 82, and the inspection process of the above (7). The chemical-strengthening process prepared the chemical-strengthening liquid containing the mixture of a potassium nitrate and a sodium nitrate, heated this chemical-strengthening solution at 380 degrees C, was immersed in the glass substrate [finishing / above-mentioned washing and desiccation] for about 4 hours, performed chemical-strengthening processing, to a sulfuric acid, neutral detergent, pure water, pure water, and each washing tub of IPA and IPA (steam seasoning), it carried out sequential immersion, cleaned ultrasonically the glass substrate which finished the chemical strengthening, and dried it to them.

[0101] When the 0.4mm flake was cut down and it measured about the obtained glass substrate using the polarization microscope, it was checked that the chemical-strengthening layer is formed. A glass substrate did not destroy the glass substrate of this example at the time of handling of the inside of said polish process, a process, and a process. About the obtained magnetic disk, when the touch-down height test was carried out, the touch-down height showed 5nm and a good value. Moreover, even if it performed the load unload trial (100,000 times), a head did not crash.

[0102]

[Effect of the Invention] The glass substrate for information record media of this invention is excellent in abrasion-proof nature, and it is lightweight, its drag force to destructive advance, i.e., fracture toughness, is large, and the breakage under industrial processing, such as a magnetic disk, and breakage in use [as an information record medium] can reduce it sharply compared with the conventional glass substrate for information record media. Furthermore, since it can mass-produce at cost comparable as a commercial glass substrate also as glass, or low, it is greatly expectable as a cheap glass substrate for next-generation magnetic-recording media.

[Translation done.]

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TECHNICAL FIELD

[Field of the Invention] This invention relates to the magnetic information record medium which used the glass substrate for information record media, and it. In more detail, this invention excels in abrasion-proof nature and is lightweight, and it is related with the magnetic information record medium using the glass substrate for information record media with big fracture toughness, and this glass substrate for information record media represented by the hard disk.

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PRIOR ART

[Description of the Prior Art] Conventionally, aluminum, glass, the ceramics, etc. have been used as a substrate ingredient for magnetic information record media. According to current, size, or an application, aluminum and glass are mainly put in practical use. In it, a glass substrate has little surface discontinuity, and since smooth nature and surface hardness are excellent, the use range is being expanded every year. As glass used as a substrate for magnetic information record media, the chemically strengthened glass by the ion-exchange method, glass ceramics, etc. are known. As chemically strengthened glass, it is a weight % display and the glass substrate for magnetic disks by which formed the compressive-stress layer on the surface of the glass substrate, and the chemical strengthening was carried out by the ion-exchange method according the glass containing 2:50 - 65% of SiO(s), 2O3:0.5 - 14% of aluminum, R2O(however, R alkali-metal ion):10-32%, ZnO:1-15%, and B-2O3:1.1-14% to alkali ion is indicated by JP,1-239036,A, for example. Moreover, as glass ceramics, it is in a U.S. Pat. No. 5391522 specification, for example, By weight % display, 2:65 - 83% of SiO(s), Li2O:8-13%, K2O:0-7%, MgO: — 0.5 - 5%, ZnO:0-5%, and PbO:0-5% — however MgO+ZnO+PbO: The glass-ceramics substrate for magnetic disks including Li2O and a 2SiO2 crystal-grain child detailed as a main crystal is indicated 0.5-5% and P2O5:1-4% including 2O3:0 - 7% of aluminum, and 2O3:0 - 2% of As2O3+Sb(s).
[0003] However, since information recording apparatus, such as a magnetic disk represented by the hard disk in recent years, are asked for the densification of record, and the writing of data and improvement in the speed of reading, improvement in the speed of disk rotation is needed for them. Although the rotational speed of a current disk is 7200rpm extent, accelerating more than 15000rpm or it in the future is expected. This demand is considered to become still stronger by especially the hard disk drive for servers that processes a lot of data. However, if the rotational frequency of a record medium is raised, a deflection will arise in a record medium, resonance will become large, and the danger that the front face of a record medium will collide with the magnetic head, and will read, and an error and the magnetic head will crash will become high. Therefore, since distance (surfacing distance) of the magnetic head and a record medium cannot be made small to some extent below in the present record medium, it is becoming the inhibition factor of the increment in recording density of a magnetic recording medium. The deflection of this record medium and the problem of resonance are solved by use of the rate substrate ingredient of high elasticity.
[0004] However, the motion to which it tends to thicken a substrate and tends to correspond to high-speed rotation-ization of a hard disk since an elastic modulus is 80 - 100GPa extent in 72GPa extent and cannot respond to high-speed rotation-ization yet is coming out of a glass substrate the aluminum substrate generally used so far. Since the increase of thickness of a substrate is accompanied by the increase of weight, the power [exhausting] of rotation[high-speed]-izing becomes large. Therefore, a substrate ingredient lighter than an aluminium alloy with a large consistency (2.76 g/cm3) is called for from a commercial scene. Moreover, an aluminum substrate has a possibility of denting the front face of a record medium in the collision of a high-speed rotation substrate and the magnetic head, in order that plastic deformation may tend to break out [surface hardness] low far from glass. On the other hand, although the glass substrate excels the aluminum substrate in an elastic modulus, surface hardness, and surface smooth nature, since it is weaker than an aluminum substrate, it is easy to get damaged, and existence of few blemishes formed in a production process leads to breakage. For example, when using glass as a magnetic-disk substrate, many processing processings, such as circular processing and heart omission and inside-and-outside periphery side processing, are needed. During these processing processings, too, many blemishes which can serve as a destructive radix point in the glass edge section etc. occur, and few blemishes formed only in a production process at the time of wearing and the other handling by the spindle lead to substrate breakage. This problem becomes more important especially with improvement in the speed of magnetic-disk rotation. In order to solve these problems, it is necessary to offer high, the drag force, i.e., fracture toughness, over destructive advance of the substrate glass with which a consistency cannot get damaged easily small, or glass, substrate glass.

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EFFECT OF THE INVENTION

[Effect of the Invention] The glass substrate for information record media of this invention is excellent in abrasion-proof nature, and it is lightweight, its drag force to destructive advance, i.e., fracture toughness, is large, and the breakage under industrial processing, such as a magnetic disk, and breakage in use [as an information record medium] can reduce it sharply compared with the conventional glass substrate for information record media. Furthermore, since it can mass-produce at cost comparable as a commercial glass substrate also as glass, or low, it is greatly expectable as a cheap glass substrate for next-generation magnetic-recording media.

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TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] This invention is the basis of such a situation, and when the consistency which can respond to rotation[high-speed]-izing or a high recording density-ized trend is small, and it excels in abrasion-proof nature and a blemish cannot be attached easily, it aims at offering the drag force to destructive advance, i.e., the glass substrate for information record media with big fracture toughness, and the magnetic information record medium using it.

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MEANS

[Means for Solving the Problem] In order that this invention persons may attain said purpose, as a result of repeating research wholeheartedly, the glass substrate below a value with the brittleness index value measured in underwater and/or a desiccation ambient atmosphere or the glass substrate which consists of glass of a specific presentation came to complete this invention for that purpose being suited as a glass substrate for information record media based on a header and this knowledge.
[0007] Namely, the glass substrate for information record media with which a brittleness index value [in / in this invention / (1) underwater] is characterized by being 1/2 or less [12 micrometers -] (Glass substrate for information record media I is called hereafter.) The glass substrate for information record media characterized by a brittleness index value [in / in (2) dew-points / an ambient atmosphere -5 degrees C or less] being 1/2 or less [7 micrometers -] (the glass substrate II for information record media is called hereafter.) A (3) underwater brittleness index value is 1/2 or less [12 micrometers -]. And the glass substrate for information record media characterized by a brittleness index value [in / in a dew-point / an ambient atmosphere -5 degrees C or less] being 1/2 or less [7 micrometers -] (the glass substrate III for information record media is called hereafter.) By (4) mol %, while more SiO(s)2, and B-2s O3 and/or aluminum 2O3 than 65% are included with the total quantity 0 - 20% (at least one sort as which R is chosen from Mg, calcium, Zn, Sr, and Ba) of RO (s), R'2O(at least one sort as which R' is chosen from Li, Na, and K) 0 - 28%, The above (1) which the sum total content of the above-mentioned component becomes from the glass which is 95% or more, including TiO2 0-10% and 20 - 10% of ZrO(s), (2), or the glass substrate for information record media given in (3), [0008] (5) At mol %, they are 2 2 - 45% of SiO(s), and R'2O (it Li(s) R'). 40 - 75%, B-2 O3, and/or aluminum 2O3 The glass substrate for information record media characterized by the sum total content of SiO2, B-2s aluminum [O3 and] 2O3, and R'2O consisting of glass which is 90% or more, including 0 - 40% per sort [at least] chosen from Na and K (the glass substrate IV for information record media is called hereafter.) The glass substrate for information record media given in the above (5) whose (6) underwater brittleness index value is 1/2 or less [12 micrometers -], (7) The above (5) whose brittleness index value [in / in a dew-point / an ambient atmosphere -5 degrees C or less] is 1/2 or less [7 micrometers -], or the glass substrate for information record media given in (6), (8) The above (1) whose Young's modulus is 70 or more GPas thru/or the glass substrate for information record media given in any 1 term of (7), (9) In the temperature field beyond the above (1) whose rigidity is 20 or more GPas thru/or the glass substrate for information record media given in any 1 term of (8), and (10) liquid-phase temperature The above (1) which viscosity becomes from the glass which has the field which are more than 1Pa and s thru/or the glass substrate for information record media given in any 1 term of (9), [0009] (11) The above (1) which a coefficient of thermal expansion becomes from the glass which is more than 60x10-7/degree C in the temperature of 100-300 degrees C thru/or the glass substrate for information record media given in any 1 term of (10), (12) The above (1) which does not have a chemical-strengthening layer thru/or the glass substrate for information record media given in any 1 term of (11), (13) The above (1) which has a chemical-strengthening layer thru/or the glass substrate for information record media given in any 1 term of (11), And the magnetic information record medium characterized by having a magnetic-recording layer at least on the glass substrate for information record media (14) above (1) thru/or given in any 1 term of (13) is offered.
[0010]
[Embodiment of the Invention] There are four modes, i.e., glass substrate I-IV for information record media, in the glass substrate for information record media of this invention. A brittleness index value [in / in glass substrate I for information record media of this invention / underwater] is 1/2 or less [12 micrometers -] glass substrate. A brittleness index value underwater [this] serves as a glass substrate which is not weak, so that that value is low. A brittleness index value underwater [this] is 1/2 or less [8 micrometers -] still more preferably 1/2 or less [9 micrometers -] more preferably 1/2 or less [10.5 micrometers -]. When an underwater brittleness index value is such a value, the destruction at the time of polish processing of a glass substrate performed in the condition of having flooded with polish liquid, and handling of the glass substrate in the condition of having wetted wet in polish liquid and a penetrant remover stops being able to happen easily.
[0011] A brittleness index value [in / glass substrate / II / of this invention / for information record media / in a dew-point / an ambient atmosphere -5 degrees C or less] is 1/2 or less [7 micrometers -] glass substrate. This index value is 1/2 or less [4 micrometers -] still more preferably 1/2 or less [5 micrometers -] more

preferably 1/2 or less [6 micrometers -]. When a brittleness index value [in / in a dew-point / an ambient atmosphere, i.e., a desiccation ambient atmosphere, -5 degrees C or less] is such a value, in a desiccation ambient atmosphere, destruction cannot take place easily at the time of handling the glass substrate for information record media, and the time of use of the information record medium using this glass substrate.
[0012] A brittleness index value [in / in the glass substrate III for information record media of this invention / underwater] is 1/2 or less [12 micrometers -], and a brittleness index value [in / in dew-point / ambient atmosphere -5 degrees C or less] is 1/2 or less [7 micrometers -] glass substrate. A brittleness index value underwater [above-mentioned] is 1/2 or less [8 micrometers -] still more preferably 1/2 or less [9 micrometers -] more preferably 1/2 or less [10.5 micrometers -], and the brittleness index value in the ambient atmosphere of the -5 degrees C or less of the above-mentioned dew-points is 1/2 or less [4 micrometers -] still more preferably 1/2 or less [5 micrometers -] more preferably 1/2 or less [6 micrometers -]. This glass substrate III is equipped with the property of both said glass substrates I and II, and even if it uses it for the bottom of what kind of environment or handles, destruction cannot take place easily.
[0013] ["a journal OBU JI American chemical society (J. Am.Chem.Soc.)" which adopts the brittleness index value B proposed by B.R.Lawn and others as a brittleness index value of said glass substrate in this invention -- the 62nd volume, and the 347th - 350-page (1979)]. Here, the brittleness index value B is defined from the Vickers hardness value Hv and the fracture toughness value Kc of glass to formula B=Hv/Kc.
[0014] The Vickers hardness value Hv and the fracture toughness value Kc of glass can do ** measured by the approach of stuffing the sharp diamond indenter of a Vickers hardness meter into glass. That is, the degree of hardness of glass is called for by the degree type from the magnitude of the indentation of the indenter which remains on the surface of glass, when the Vickers indenter is pushed in.
[0015]
[Equation 1]

$$Hv = 1.8544 \times \frac{P}{(2a)^2}$$

[0016] Here, P is the pushing load of the Vickers indenter and a is the diagonal line length of the Vickers indentation. On the other hand, the fracture toughness Kc of glass is searched for by the degree type from the magnitude of the indentation of the indenter which remains on the surface of glass, and the die length of the crack generated from the corner of an indentation, when the Vickers indenter is pushed in.
[0017]
[Equation 2]

$$Kc = 0.026 \frac{E^{\frac{1}{2}} P^{\frac{1}{2}} a}{C^{\frac{3}{2}}}$$

[0018] Here, E is the Young's modulus of glass, and the die length of the crack which generates C from the corner of an indentation. The requirement for calculating Kc correctly is that a C/a ratio becomes large 2.5 or more.
[0019] the approach shown in JP,10-158028,A which indicates this example of a comparison in this invention in order to compare with the below-mentioned example of a comparison although the brittleness index value B of glass was computed by Hv and Kc which were calculated above to B=Hv/Kc -- namely [0020]
[Equation 3]

$$B = 2.39 \times \left[\frac{C}{\alpha}\right]^{\frac{3}{2}} P^{\frac{1}{4}}$$

[0021] The value which was boiled and was computed more is adopted.
[0022] Since most differences with the value of the brittleness evaluated by the value and Hv/Kc equation of the brittleness using the formula shown in JP,10-158028,A are 5% or less, even if it uses the equation shown in JP,10-158028,A, it can evaluate correctly. The formula shown in JP,10-158028,A in fact used Lawn's and others Hv/Kc formula as the base, and was drawn, and its fundamental concept is the same.
[0023] An underwater brittleness index value drops the waterdrop of pure water on a sample front face, after 30 seconds, pushes in the Vickers indenter from on the waterdrop, and introduces an indentation and a crack. After that, it is immersed into pure water, a sample is taken out 24 hours after immediately, water is wiped off, and it is the value which measured and computed the magnitude of an indentation and a crack immediately. Moreover, while a brittleness index value [in / in a dew-point / an ambient atmosphere -5 degrees C or less] measures the dew-point of the sample circumference under desiccation nitrogen-gas-atmosphere mind and checks that this dew-point is -5 degrees C or less, the Vickers indenter is pushed in and an indentation and a crack are introduced, and it is the value computed by having measured those magnitude.
[0024] Since it has the above brittleness index values, when a blemish cannot be attached easily, since a chemical strengthening equivalent to conventional glass is also possible, the glass substrates I, II, and III for

information record media of this invention can decrease breakage in use sharply as the breakage in a production process, and a product.

[0025] As such glass substrate I-III, it is mol% as a glass presentation. While more SiO(s)2, and B-2s O3 and/or aluminum 2O3 than 65% are included with the total quantity 0 - 20% (at least one sort as which R is chosen from Mg, calcium, Zn, Sr, and Ba) of RO(s), What the sum total content of the above-mentioned component becomes from the glass which is 95% or more can be mentioned including R'2O(at least one sort as which R' is chosen from Li, Na, and K) 0 - 28%, TiO2 0-10%, and ZrO2 0-10%.

[0026] this glass presentation -- setting -- the sum total content of SiO2, and B-2 O3 and/or aluminum 2O3 -- desirable -- 65-mol % -- many -- less than [90 mol %] -- more -- desirable -- 70-90-mol % -- it is the 70-85-mol range of % still more preferably. moreover, the content of SiO2 -- desirable -- 40-75-mol % -- more -- desirable -- 50-70-mol % -- it is -- the content of aluminum 2O3 -- desirable -- 0-25-mol % -- more -- desirable -- 1-20-mol % -- it is 2-15-mol % still more preferably. the content of B-2 O3 -- desirable -- 0-25-mol % -- more -- desirable -- 1-25-mol % -- it is 2-20-mol % still more preferably. said content of RO -- desirable -- less than [15 mol %] -- it is less than [12 mol %] more preferably. moreover, the content of MgO -- desirable -- less than [15 mol %] -- more -- desirable -- less than [12 mol %] -- it is -- the content of CaO -- desirable -- less than [10 mol %] -- it is less than [8 mol %] more preferably. the content of ZnO -- desirable -- less than [10 mol %] -- more -- desirable -- less than [8 mol %] -- it is -- the content of SrO -- desirable -- less than [10 mol %] -- it is less than [8 mol %] more preferably. the content of BaO -- desirable -- less than [10 mol %] -- it is less than [5 mol %] more preferably. As this RO, MgO is desirable.

[0027] the content of R'2O -- desirable -- less than [25 mol %] -- it is 10-25-mol % more preferably. moreover, the content of Li2O -- desirable -- less than [20 mol %] -- more -- desirable -- less than [18 mol %] -- further -- desirable -- 5-15-mol % -- it is -- the content of Na2O -- desirable -- less than [20 mol %] -- more -- desirable -- less than [15 mol %] -- it is 1-10-mol % still more preferably. the content of K2O -- desirable -- less than [15 mol %] -- more -- desirable -- less than [10 mol %] -- it is 0-8-mol % still more preferably. moreover, SiO2 and B-2s O3 and aluminum2 -- the sum total content of O3, RO, and R'2O -- desirable -- more than 85 mol % -- more -- desirable -- more than 90 mol % -- it is more than 95 mol % still more preferably.

[0028] furthermore, the content of TiO2 -- desirable -- 0-7-mol % -- more -- desirable -- 0-5-mol % -- it is -- the content of ZrO2 -- desirable -- 0-8-mol % -- it is 0-6-mol % more preferably. moreover, SiO2 and B-2s O3 and aluminum2 -- the sum total content of O3, RO, R'2O, and TiO2 and ZrO2 -- desirable -- more than 95 mol % -- it is more than 98 mol % more preferably. Furthermore, the mole ratio (B-2s O3/aluminum 2O3) of B-2s aluminum [O3 and] 2O3 has the desirable range of 0.5-1.5, and it is the range of 0.8-1.2 more preferably.

[0029] As a combination of the above component, it is mol%, for example and is SiO2. 40 - 75%, B-2O3 1-20% (however, the sum total content of SiO2 and B-2s aluminum [O3 and] 2O3 exceeds 65%.) 1 - 25%, aluminum 2O3 MgO 0-10% (however, the sum total content of MgO, CaO and ZnO, and SrO and BaO is less than 20%.) 0 - 15%, ZnO 0 - 10%, CaO 0 - 10%, SrO 0 - 10%, BaO Li2O 0 - 20%, Na2O 0 - 20%, K2O 0 - 15% (However, the sum total content of Li2O, Na2O, and K2O is less than 28%.) TiO2 0 - 10%, and ZrO2 glass ****** whose sum total content of the above-mentioned component is 95% or more, including 0 - 10% -- things are made.

[0030] SiO2 is a principal component which forms the network structure of glass, less than [40 mol %], the endurance of glass gets worse and glass becomes easy to devitrify the content. On the other hand, if 75-mol % is exceeded, elevated-temperature viscosity will become high and glass will stop being able to melt easily. Therefore, the content of SiO2 has the desirable 40-75-mol range of %, and its the 50-70-mol range of % is especially desirable.

[0031] B-2 O3 is the important component of this invention. If B-2 O3 is introduced instead of SiO2, when the brittleness of glass will fall sharply and will become low [specific gravity], elevated-temperature viscosity also falls and the solubility of glass is improved greatly. However, when the amount of installation increases exceeding 25-mol %, the endurance of glass gets worse, and since it becomes easy to carry out phase splitting, there is a case where it becomes impossible to make good glass. On the other hand, since brittleness gets worse [the amount of installation] less than [1 mol %] and elevated-temperature viscosity also becomes high, there is a possibility that fertilization of low cost may become impossible. Therefore, 1-25-mol% of the content of B-2 O3 is desirable, and its the 2-20-mol range of % is especially desirable.

[0032] aluminum 2O3 is very important also as a component which raises whenever [stabilization / of glass structure /, and its rigidity] with SiO2 also as a component which contributes thermal resistance, and endurance and low brittleness to glass. However, if the effectiveness that the content stops the elution of the alkali from glass less than [1 mol %] is small, it is hard to make glass with sufficient endurance and it introduces exceeding 20-mol %, since the elevated-temperature melting nature of glass will get worse, the content has the desirable 1-20-mol range of %, and it is the 2-15-mol range of % more preferably.

[0033] MgO, CaO, ZnO, SrO, and BaO are the components introduced in order to lower the viscosity at the time of the dissolution of glass and to raise melting nature and mass-production nature. Since brittleness becomes [a sum total content] high more than at 20 mol %, there is an inclination for glass to become easy to get damaged and for specific gravity and devitrification temperature to also become high. Both soluble [of glass] and low brittle are taken into consideration. The content of MgO, CaO, ZnO, SrO, and BaO MgO -- 0-15-mol % -- desirable -- 0-12-mol % and ZnO -- 0-10-mol % -- desirable -- 0-8-mol % and CaO -- 0-10-mol % -- desirable -- 0-8-mol % -- SrO -- 0-10-mol % -- desirable -- 0-8-mol % and BaO -- 0-10-mol % --

desirable — the 0-5-mol range of % — it is — those sum total contents -- desirable — less than [20 mol %] — it is less than [15 mol %] more preferably.
[0034] Li2O, Na2O, and K2O are a very useful component which makes brittleness of glass low while they lower the viscosity at the time of the dissolution of glass and promote the dissolution. However, since chemical durability not only gets worse, but there is a possibility of eating a magnetic film away in order for alkali to deposit on a glass front face mostly when the amount of installation becomes 28% or more Li2O the content of Li2O, Na2O, and K2O 0-20-mol %, desirable — 0-18-mol % and 2O0-20 mol [of Na] % — desirable -- 0-15-mol %, and K 2O0-15-mol % — while considering as 0-10-mol % preferably — those sum total contents -- desirable — less than [28 mol %] — it holds down to less than [25 mol %] more preferably.
[0035] the sum total content of SiO2 and B-2s aluminum [O3 and] 2O3 — desirable — 70-90-mol % — more — desirable — the 80-90-mol range of % — it is — the sum total content of RO and R'2O — desirable — 5-35-mol % — more — desirable — 10-30-mol % — further — desirable — 10-25-mol % — it is 10-22-mol % especially preferably.
[0036] ZrO2 and TiO2 are components introduced in order to raise the chemical durability of glass and to raise whenever [rigid]. If ZrO2 and TiO2 are added on glass, the endurance of glass, an elastic modulus, and brittleness will be improved, but specific gravity increases rapidly, and if it introduces more mostly, the devitrification inclination of glass will become strong. [little] therefore, the content of ZrO2 and TiO2 — respectively — 0-10-mol % — desirable — 0-7-mol % and 0-10-mol % — it is preferably restricted to 0-8-mol%. Moreover, the sum total content of the above-mentioned component is more than 95 mol %.
[0037] Since the solubility of glass, clarity, a moldability, etc. are improved on this glass in addition to the above-mentioned component, on it, it is possible to introduce As 2O3, Sb2O3, and F, Cl and SO3 into less than [2 mol %] in total. Moreover, since the endurance and the elastic modulus of glass are raised, other oxides, such as rare earth metal oxides, such as Y2O3 and La2O3, can be added at a rate not more than 5 mol %.
[0038] Furthermore, it is SiO2 at mol %. 55 - 75%, B-2 O3 0 - 20%, 2O31 - 20% (however, the sum total content of SiO2 and B-2s aluminum [O3 and] 2O3 65% or more) of aluminum, MgO 0 - 15%, ZnO 0 - 10%, CaO 0 - 10%, 0 - 10% of SrO(s), BaO 0 - 10% (however, the sum total content of MgO, CaO and ZnO, and SrO and BaO (the content of RO) 20% or less), Li2O 0 - 20%, Na2O 0 - 20%, K2O 0 - 6% (— however, the sum total content (R'2O content) of Li2O, Na2O, and K2O — less than [28%]) and TiO2 0 - 10%, and ZrO2 The sum total content of the above-mentioned component can also mention 95% or more of glass, including 0 - 10%.
[0039] The glass substrate IV for information record media of this invention is SiO2 at mol %. 40 - 75%, B-2 O3 and/or aluminum 2O3 The sum total content of SiO2, B-2s aluminum [O3 and] 2O3, and R'2O consists of glass which is 90% or more, including 2 - 45%, and R'2O(at least one sort as which R' is chosen from Li, Na, and K) 0 - 40%.
[0040] this glass presentation — setting — the content of SiO2 — 50-70-mol % — desirable — the content of B-2 O3 — desirable — 0-25-mol % — more — desirable — 1-25-mol % — further — desirable — 2-20-mol % — it is — the content of aluminum 2O3 — desirable — 0-25-mol % — more — desirable — 1-20-mol % — it is 2-15-mol % still more preferably. the sum total content of SiO2 and B-2s aluminum [O3 and] 2O3 — desirable — 65-90-mol % — more — desirable — 70-90-mol % — it is 70-85-mol % still more preferably. an R'2O content — desirable — 0-28-mol % (however, 0 is removed when RO is zero-mol %) — more — desirable — less than [25 mol %] — it is 10-25-mol % still more preferably. It is 5-15-mol % still more preferably. the content of Li2O — desirable — less than [20 mol %] — more — desirable — less than [18 mol %] — the content of Na2O desirable — less than [20 mol %] — more — desirable — less than [15 mol %] — further — desirable — 1-10-mol % — it is — the content of K2O — desirable — less than [15 mol %] — more — desirable — less than [10 mol %] — it is 0-8-mol % still more preferably. furthermore, the content of RO — desirable — less than [15 mol %] — it is less than [12 mol %] more preferably. moreover, the content of MgO — desirable — less than [15 mol %] — more — desirable — less than [12 mol %] — it is — the content of CaO — desirable — less than [10 mol %] — it is less than [8 mol %] more preferably. the content of ZnO — desirable — less than [10 mol %] — more — desirable — less than [8 mol %] — it is — the content of SrO — - desirable — less than [10 mol %] — it is less than [8 mol %] more preferably. the content of BaO — desirable — less than [10 mol %] — it is less than [5 mol %] more preferably. Especially as RO, MgO is desirable.
[0041] the sum total content of RO and R'2O — desirable — 5-35-mol % — more — desirable — 10-30-mol % — further — desirable — 10-25-mol % — it is 10-22-mol % especially preferably. Furthermore, TiO2 0-10-mol % can be included and the desirable content of TiO2 is 0-7-mol %. Moreover, ZrO2 0-10-mol % can be included and ZrO2 desirable content is 0-7-mol %.
[0042] This glass substrate IV can make an underwater brittleness index value more preferably 1/2 or less [8 micrometers -] still more preferably 1/2 or less [9 micrometers -] 1/2 or less [10.5 micrometers -] 1/2 or less [12 micrometers -]. Moreover, a dew-point can make more preferably the brittleness index value in an ambient atmosphere -5 degrees C or less still more preferably 1/2 or less [4 micrometers -] 1/2 or less [5 micrometers -] 1/2 or less [6 micrometers -] 1/2 or less [7 micrometers -].
[0043] In glass substrate I-IV for information record media of this invention, 70 or more GPas of 75 or more GPas of Young's modulus can be more preferably set to 85 or more GPas.
[0044] It is desirable to raise the Young's modulus of a glass substrate from from [when carrying out high-speed rotation of the information record medium containing the glass substrate of thin meat and the glass

substrate concerned prevents deforming by resonance etc.]. For example, when rotating the diameter of 3.5 inches and the magnetic disk produced using the glass substrate with a thickness of 0.635mm with which Young's modulus consists of glass of 70 or more GPas by 10000rpm, the premature start height of the magnetic disk and the record reproducing head concerned can be secured to stability in general by 1 micrometer or less.
[0045] moreover, in a glass substrate with an underwater low brittleness index value, when Young's modulus is 70 or more GPas further, the destruction at the time of handling the glass substrate in the condition of having wetted the glass substrate wet in the condition of having flooded with polish liquid, by grinding, the crack at the time of grinding, polish liquid, or the penetrant remover is markedly alike, and stops being able to happen easily
[0046] Furthermore, in a glass substrate with the low brittleness index value underwater and/or in a desiccation ambient atmosphere, since a glass substrate cannot bend easily due to rotation or a load when Young's modulus is 70 or more GPas further, the destruction at the time of especially an information record medium carrying out high-speed rotation stops being able to happen further easily at the time of polish processing of a glass substrate and information record-medium use.
[0047] Moreover, in glass substrate I-IV of this invention, 20 or more GPas of 25 or more GPas of rigidity can be more preferably set to 30 or more GPas.
[0048] It is desirable to raise the rigidity of a glass substrate from from [when carrying out high-speed rotation of the information record medium containing the glass substrate of thin meat and the glass substrate concerned prevents deforming by resonance etc.]. For example, when rigidity rotates the diameter of 3.5 inches and the magnetic disk produced using the glass substrate with a thickness of 0.635mm which consists of glass of 20 or more GPas by 10000rpm, the premature start height of the magnetic disk and the record reproducing head concerned can be secured to stability in general by 1 micrometer or less.
[0049] moreover, in a glass substrate with an underwater low brittleness index value, when rigidity is 20 or more GPas further, the destruction at the time of handling the glass substrate in the condition of having wetted the glass substrate wet in the condition of having flooded with polish liquid, by grinding, the crack at the time of grinding, polish liquid, or the penetrant remover is markedly alike, and stops being able to happen easily
[0050] Furthermore, in a glass substrate with the low brittleness index value underwater and/or in a desiccation ambient atmosphere, since a glass substrate cannot bend easily due to rotation or a load when rigidity is 20 or more GPas further, the destruction at the time of especially an information record medium carrying out high-speed rotation stops being able to happen further easily at the time of polish processing of a glass substrate and information record-medium use.
[0051] Moreover, in glass substrate I-IV of this invention, a specific Young's modulus (value which **(ed) Young's modulus by the consistency) is 27x106 or more N-m/kg. This specific Young's modulus can set the deflection at the time of high-speed rotation of an information record medium to 2 micrometers or less, and can secure and carry out the thing of the premature start height to stability in 1 micrometer or less as that result at 27x106 or more N-m/kg. Moreover, in a glass substrate with a small brittleness index value, destruction stops being able to happen further easily due to there being few deflections at the time of high-speed rotation. As for this specific Young's modulus, it is more desirable that they are 30x106 or more N-m/kg.
[0052] Moreover, in glass substrate I-IV of this invention, a consistency can also be preferably made into three or less 2.50 g/cm three or less 2.65 g/cm. Furthermore, in glass substrate I-IV of this invention, they are 1/2 or more 0.83 MPa/m more preferably 1/2 or more 0.80 MPa/m 1/2 or more 0.75 MPa/m about a fracture toughness value. The destruction [be / fracture toughness values / 1/2 or more 0.75 MPa/m] at the time of glass substrate processing and use of an information record medium stops being able to happen easily.
[0053] In glass substrate I-IV for information record media of this invention, what viscosity becomes from the glass which has the field which is 1 or more Pa-s is desirable in the temperature field beyond liquid phase temperature.
[0054] In order to obtain the glass substrate for information record media, it is necessary to make it not devitrify substantially by the production process, and to perform the dissolution of a raw material and supply to the die of dissolved glass at least for that purpose above liquid phase temperature. For this reason, it is desirable to make liquid phase temperature of ingredient glass into 1350 degrees C or less in glass substrate I-IV of this invention, it is more desirable that it is 1250 degrees C or less, and it is desirable that it is especially 1150 degrees C or less.
[0055] Here, it becomes difficult to obtain the flat glass substrate for information record media with thin meat by about [that control of the flow rate of melting glass becomes it difficult that the viscosity at the time of supplying melting glass to a die is less than 1 Pa-s] and press forming. In addition, as for glass substrate I-IV of this invention, what consists of glass which has the field whose viscosity is 3 or more Pa-s in the temperature field beyond liquid phase temperature is more desirable.
[0056] The transition point of ingredient glass can be made into 470-640 degrees C in glass substrate I-IV of this invention. If a glass transition point is too high, the temperature field which can carry out press forming will become narrow, it is hard coming to carry out press forming of the glass substrate of thin meat, and after [which will, on the other hand, form magnetic films such as a record layer, in a glass substrate if a glass transition point is too low] forming in the case, the range of the heat-treatment temperature performed for the purpose, such as improvement in magnetic properties, becomes narrow. The range of the desirable transition point is 470-620 degrees C.
[0057] In glass substrate I-IV for information record media of this invention, what a coefficient of thermal

expansion becomes from the glass which is more than 60x10-7/degree C in the temperature of 100-300 degrees C is desirable. In case information is recorded on information record media, such as a magnetic disk, an optical disk, and a magneto-optic disk, or in case the information currently recorded on the information record medium concerned is reproduced, the information record medium concerned rotates, after having been fixed to the spindle of the drive motor prepared in the information processor by the clamp, but if the coefficient of thermal expansion of an information record medium differs from the coefficient of thermal expansion of the aforementioned clamp remarkably in this case, the following problems will arise.

[0058] Namely, although temperature, such as an information record medium, a spindle, and a clamp, carries out a temperature up rapidly to about 90 degrees C by generation of heat of a drive motor etc. in case an information record medium is rotated If the coefficient of thermal expansion of an information record medium differs from the coefficient of thermal expansion of the aforementioned clamp remarkably Slack arises between an information record medium and a clamp according to the aforementioned temperature up, or distortion and bending arise in an information record medium, and the location of the data-logging part (truck) in an information record medium changes as the result, and it becomes easy to produce an error in informational record or playback. Such a problem turns into a problem with a big substrate like 3.5 inches especially.

[0059] Therefore, as for the coefficient of thermal expansion of glass substrate I-IV of this invention, it is desirable to resemble the coefficient of thermal expansion of the aforementioned clamp as much as possible. since the aforementioned clamp is generally produced with the stainless alloy, the coefficient of thermal expansion in 100-300 degrees C of glass substrate I-IV of this invention is more than 60x10-7/degree C -- desirable -- more -- desirable -- more than 70x10-7/degree C -- further -- desirable -- 70x10-7/degree-C - 120x10-7/degree C -- it is 80x10-7/degree-C - 100x10-7/degree C especially preferably.

[0060] Glass substrate I-IV for information record media of this invention may not have the chemical-strengthening layer, by request, may perform well-known chemical-strengthening processing, and may prepare a chemical-strengthening layer. When performing chemical-strengthening processing, it is good to choose the presentation suitable for chemical-strengthening processing from the range of the above-mentioned glass presentation.

[0061] Chemical-strengthening processing can be performed by the ion-exchange method. This ion-exchange method is performed using the fused salt containing Na ion and K ion, and chemically strengthened glass is obtained. Although it is desirable as processing fused salt containing Na ion and K ion to use a sodium nitrate, a potassium nitrate, and its mixed fused salt, it is not limited to a nitrate and a sulfate, a bisulfate, a carbonate, a halogenide, etc. may be used. As mentioned above, since the glass used by this invention has low brittleness quantity fracture toughness and flexural strength also becomes high according to the ion exchange, the obtained chemically strengthened glass has the outstanding destructive resistance.

[0062] As the manufacture approach of the glass substrate for information record media of this invention, there is especially no limit and it can use various kinds of approaches. For example, the raw materials for glass of elevated-temperature scorification, i.e., a predetermined rate, are dissolved in the inside of air, or an inert gas ambient atmosphere, bubbling, stirring, etc. perform homogenizing of glass, it is fabricated by sheet glass with the pressing method, the well-known down draw method, and a well-known float glass process, circular processing and heart omission, inside-and-outside periphery processing, grinding, polish, etc. are given after that, and it considers as the substrate for information record media of desired size and a configuration. In addition, by polish, surface precision can be made into the range of 0.1-0.6nm by performing polishing processing by abrasives, such as lap INGU and cerium oxide, with abrasives or a diamond pellet.

[0063] On glass substrate I-IV for information record media of above-mentioned this invention, the magnetic information record medium of this invention has a magnetic-recording layer at least, and can mention the configuration which prepared the substrate layer, the magnetic-recording layer, the protective layer, and the lubricating layer one by one on said glass substrate as a configuration of this magnetic information record medium, for example.

[0064] Here, as a magnetic-recording layer, a Co-Cr system, a Co-Cr-Pt system, a Co-nickel-Cr system, a Co-nickel-Pt system, a Co-nickel-Cr-Pt system, a Co-Cr-Ta system, etc. can be used, for example. As a substrate layer, nickel layer, a nickel-P layer, Cr layer, etc. can be used, for example, the carbon film etc. can be used as a protective layer, for example, and lubricant, such as a perfluoro polyether system, can be used as a lubricating layer, for example.

[Translation done.]

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EXAMPLE

[Example] Next, although an example explains this invention to a detail further, this invention is not limited at all by these examples.
[0066] In addition, the physical properties of the glass obtained in each example were measured according to the approach shown below.
(1) The sample with a Young's modulus of 20x20x100mm was produced, and after measuring the longitudinal-wave rate (Vl) and transverse-wave rate (Vs) at the time of a 5MHz supersonic wave spreading the inside of the aforementioned sample using a SHINGUA round type acoustic-velocity measuring device (UVM-2 by the ultrasonic industrial company), it asked by the degree type.
Young's modulus =(4G2-3 G-Vl2 and rho)/(G-Vl2andrho)
G=Vs2andrhorho: The consistency of a sample (g/cm3)
[0067] (2) It can ask for rigidity as G at the time of Young's modulus measurement of the rigidity above (1).
(3) After paying the liquid phase temperature sample to the container made from platinum and leaving it for 30 minutes in a gradient temperature furnace, the existence of the crystal in the front face and the interior of a sample was observed using the optical microscope. And the minimum temperature in which a crystal does not deposit was made into liquid phase temperature.
(4) A glass transition point (Tg), a surrendering point (Td)
About the 5mm phix20mm sample, it measured using the Rigaku apparatus for thermomechanical analysis (TMA8140) with +4-degree-C programming rate for /. In addition, SiO2 was used as a standard sample.
[0068] (5) The average coefficient of thermal expansion in the coefficient of thermal expansion of 100-300 degrees C was meant, and it measured together at the time of measurement of a glass transition point.
(6) it was shown all over Table 1 - 15 to the sample which processed tabular [of 2mm thickness] using the micro hardness tester (MVK-E) of a brittleness index value Akashi factory — it pushed in, the Vickers indenter was pushed in by the load, and the indentation and the crack were introduced into the sample.
[0069] When making it a value from which a probability becomes 60 or more measures an exact brittleness index value, Vickers hardness, fracture toughness, etc., it is desirable, and a pushing load has a more desirable value which becomes 70 or more, and is desirable to high-priced [which become 80 or more]. When the diagonal line length a and the Vickers indenter of the measured Vickers indentation were pushed in, die-length C of the crack generated from the corner of the Vickers indentation produced on a sample front face was measured. From the above measured value, Vickers hardness Hv, fracture toughness Kc, and the brittleness index value B were calculated using said formula (1) - (3).
[0070] In addition, in order to search for the underwater brittleness index value B, Vickers hardness Hv, fracture toughness Kc, etc., pure waterdrop is dropped on a sample front face, after 30 seconds, the Vickers indenter is stuffed into a sample from on the waterdrop, and an indentation and a crack are introduced.
[0071] Moreover, in order for a dew-point to search for the brittleness index value B in an ambient atmosphere -5 degrees C or less, Vickers hardness Hv, fracture toughness Kc, etc., under desiccation nitrogen-gas-atmosphere mind, checking that the dew-point of the sample circumference is -5 degrees C or less, the Vickers indenter is stuffed into a sample and an indentation and a crack are introduced. In addition, the probability in Table 1 - 14 is the probability of occurrence per each top-most vertices of the crack produced from each four top-most vertices of an indentation.
[0072] It is a start raw material so that the glass of the presentation shown in one to example 81 Table 1 - 14 may be obtained. SiO2, aluminum 2O3, aluminum(OH)3, B-2s O3, HBO3, and MgO, Mg (OH)2, MgCO3, CaCO3, SrCO3, BaCO3, ZnO, 300-1500g weighing capacity was carried out using Li2CO3, Na2CO3, K2CO3, TiO2, ZrO2, etc., and it fully mixed, and accomplished with the preparation batch, this was put into platinum crucible, and glass was dissolved at the temperature of 1400-1600 degrees C for about 3 to 8 hours in air. After melting, after cooling glass melt radiationally to the transition point temperature of a sink and glass to 40x40x20mm carbon metal mold, putting into the annealing furnace immediately and holding for 1 hour, it cooled radiationally to the room temperature in the furnace. A crystal to the extent that the obtained glass is observable under a microscope did not deposit. Thus, the obtained glass was processed, the sample for each physical-properties evaluation was produced, and physical-properties evaluation was performed. The result is shown in Table 1 - 14.
[0073]

[Table 1]

表 1

		実施例					
		1	2	3	4	5	6
組成（モル%）	SiO2	0.0	10.0	20.0	30.0	40.0	45.0
	B2O3	60.0	50.0	40.0	30.0	20.0	10.0
	Al2O3	12.0	12.0	12.0	12.0	12.0	15.0
	MgO	8.0	8.0	8.0	8.0	8.0	10.0
	CaO	15.0	20.0	20.0	15.0	10.0	10.0
	ZnO	—	—	—	—	—	—
	RO	23.0	28.0	28.0	23.0	18.0	20.0
	LI2O	—	—	—	—	—	5.0
	Na2O	—	—	—	0.0	5.0	5.0
	K2O	5.0	0.0	0.0	5.0	5.0	0.0
	R'2O	5.0	0.0	0.0	5.0	10.0	10.0
	TiO2	—	—	—	—	—	—
	ZrO2	—	—	—	—	—	—
	SiO2+B2O3+Al2O3	72.0	72.0	72.0	72.0	72.0	70.0
	B2O3/Al2O3	5.0	4.2	3.3	2.5	1.7	0.7
	RO+R'2O	28.0	28.0	28.0	28.0	28.0	30.0
	SiO2+B2O3+Al2O3+RO+R'2O	100.0	100.0	100.0	100.0	100.0	100.0
	SiO2+B2O3+Al2O3+R'2O	77.0	72.0	72.0	77.0	82.0	80.0
	SiO2+B2O3+Al2O3+RO +R'2O+TiO2+ZrO2	100.0	100.0	100.0	100.0	100.0	100.0
	合 計	100.0	100.0	100.0	100.0	100.0	100.0
ガラス転移点 Tg[℃]		552	612	622	590	565	554
屈伏点 Td [℃]		596	660	664	643	620	609
熱膨張係数 $\alpha \times 10^{-7}$[/℃]		67	58	59	66	79	67
密度 [g/cm³]		2.373	2.490	2.522	2.472	2.478	2.547
ヤング率 E[GPa]		65.28	80	81.4	75.52	72.71	87.97
剛性率 G [GPa]		25.56	—	—	30.21	29.30	35.19
水中	押し込み荷重 [gF]	1000	1000	1000	1000	1000	1000
	脆さ指標値 B [$\mu m^{-1/2}$]	11.0	9.4	10.6	7.7	8.2	9.8
	ビッカース硬度 Hv [GPa]	4.6	5.3	5.8	5.3	5.2	6.1
	破壊靭性 Kc [MPa/$m^{1/2}$]	0.46	0.61	0.56	0.73	0.68	0.64
	プロバビリティ	100	100	100	100	100	100
乾燥雰囲気 N2	押し込み荷重 [gF]	1000	1000	1000	1000	1000	1000
	脆さ保存性 B[$\mu m^{-1/2}$]	6.0	5.0	6.1	6.0	5.6	5.9
	ビッカース硬度 Hv [GPa]	—	—	—	5.5	5.1	6.1
	破壊靭性 Kc [MPa/$m^{1/2}$]	—	—	—	0.93	0.98	1.08
	プロバビリティ	—	—	—	100	40	100

[0074]
[Table 2]

表 2

		実施例					
		7	8	9	10	11	12
組成（モル%）	SiO2	45.0	50.0	50.0	50.0	50.0	52.4
	B2O3	20.0	10.0	10.0	10.0	20.0	23.8
	Al2O3	10.0	10.0	10.0	12.0	12.0	9.5
	MgO	10.0	10.0	10.0	8.0	8.0	0.0
	CaO	5.0	10.0	10.0	20.0	0.0	0.0
	ZnO	—	—	—	—	—	—
	RO	15.0	20.0	20.0	28.0	8.0	0.0
	Li2O	0.0	0.0	5.0	—	0.0	0.0
	Na2O	5.0	5.0	5.0	—	5.0	4.8
	K2O	5.0	5.0	0.0	0.0	5.0	9.5
	R'2O	10.0	10.0	10.0	0.0	10.0	14.3
	TiO2	—	—	—	—	—	—
	ZrO2	—	—	—	—	—	—
	SiO2+B2O3+Al2O3	75.0	70.0	70.0	72.0	82.0	85.7
	B2O3/Al2O3	2.0	1.0	1.0	0.8	1.7	2.5
	RO+R'2O	25.0	30.0	30.0	28.0	18.0	14.3
	SiO2+B2O3+Al2O3+RO+R'2O	100.0	100.0	100.0	100.0	100.0	100.0
	SiO2+B2O3+Al2O3+R'2O	85.0	80.0	80.0	72.0	92.0	100.0
	SiO2+B2O3+Al2O3+RO+R'2O+TiO2+ZrO2	100.0	100.0	100.0	100.0	100.0	100.0
	合計	100.0	100.0	100.0	100.0	100.0	100.0
ガラス転移点 Tg[℃]		548	595	541	676	543	478
屈伏点 Td [℃]		625	676	596	733	614	551
熱膨張係数 $\alpha\times10^{-7}$[/℃]		77	87	71	52	70	82
密度 [g/cm³]		2.424	2.518	2.540	2.598	2.336	2.292
ヤング率 E[GPa]		68.82	76.62	88.53	86.1	61.54	53.42
剛性率G [GPa]		27.79	31.13	35.74	—	24.84	21.63
水中	押し込み荷重 [gF]	1000	1000	1000	1000	1000	1000
	脆さ指標値 B [$\mu m^{-1/8}$]	6.9	9.3	9.7	9.6	5.7	6.6
	ビッカース硬度 Hv [GPa]	5.1	5.5	5.7	5.9	4.5	4.2
	破壊靭性 Kc [MPa/$m^{1/2}$]	0.76	0.61	0.63	0.64	0.85	0.67
	プロバビリティ	95	100	100	100	95	100
乾燥雰囲気 N2	押し込み荷重 [gF]	5980	1000	1000	1000	6952	5980
	脆さ指標値 B [$\mu m^{-1/8}$]	4.6	5.9	6.1	5.4	3.4	3.4
	ビッカース硬度 Hv [GPa]	4.9	5.5	6.1	5.7	4.4	4.2
	破壊靭性 Kc [MPa/$m^{1/2}$]	1.17	0.96	1.03	1.12	1.40	1.31
	プロバビリティ	80	100	100	85	80	40

[0075]
[Table 3]

表 3

		実施例					
		13	14	15	16	17	18
組成（モル%）	SiO2	55.0	55.0	55.0	55.0	60.0	60.0
	B2O3	10.0	15.0	20.0	25.0	10.0	10.0
	Al2O3	12.0	10.0	10.0	10.0	2.5	5.0
	MgO	8.0	10.0	5.0	0.0	10.0	10.0
	CaO	5.0	0.0	0.0	0.0	0.0	0.0
	ZnO	—	—	—	—	0.0	0.0
	RO	13.0	10.0	5.0	0.0	10.0	10.0
	Li2O	0.0	0.0	0.0	0.0	0.0	0.0
	Na2O	5.0	5.0	5.0	5.0	12.5	10.0
	K2O	5.0	5.0	5.0	5.0	5.0	5.0
	R'2O	10.0	10.0	10.0	10.0	17.5	15.0
	TiO2	—	—	—	—	0.0	0.0
	ZrO2	—	—	—	—	—	—
	SiO2+B2O3+Al2O3	77.0	80.0	85.0	90.0	72.5	75.0
	B2O3/Al2O3	0.8	1.5	2.0	2.5	4.0	2.0
	RO+R'2O	23.0	20.0	15.0	10.0	27.5	25.0
	SiO2+B2O3+Al2O3+RO+R'2O	100.0	100.0	100.0	100.0	100.0	100.0
	SiO2+B2O3+Al2O3+R'2O	87.0	90.0	95.0	100.0	90.0	90.0
	SiO2+B2O3+Al2O3+RO+R'2O+TiO2+ZrO2	100.0	100.0	100.0	100.0	100.0	100.0
	合 計	100.0	100.0	100.0	100.0	100.0	100.0
ガラス転移点 Tg[℃]		606	568	522	472	536	541
屈伏点 Td [℃]		678	659	612	558	595	606
熱膨張係数 $\alpha \times 10^{-7}$[/℃]		70	73	66	71	99	87
密度 [g/cm³]		2.439	2.365	2.307	2.238	2.470	2.442
ヤング率 E[GPa]		72.07	65.21	58.72	49.65	73.94	72.54
剛性率G [GPa]		29.43	26.60	23.83	20.02	30.32	29.74
水中	押し込み荷重 [gF]	1000	1000	1000	1000	1000	1000
	脆さ指標値 B [$\mu m^{-1/2}$]	6.7	5.9	5.8	5.4	9.7	6.3
	ビッカース硬度 Hv [GPa]	5.0	4.8	4.4	3.9	5.1	5.1
	破壊靭性 Kc [MPa/$m^{1/2}$]	0.80	0.86	0.81	0.78	0.56	0.87
	プロバビリティ	95	100	100	100	100	100
乾燥雰囲気 N2	押し込み荷重 [gF]	6952	5980	5980	5980	5980	5980
	脆さ指標値 B [$\mu m^{-1/2}$]	4.4	3.6	3.6	3.1	4.9	4.4
	ビッカース硬度 Hv [GPa]	5.0	4.7	4.4	3.9	5.2	5.3
	破壊靭性 Kc [MPa/$m^{1/2}$]	1.24	1.41	1.33	1.36	1.12	1.23
	プロバビリティ	100	100	100	60	100	80

[0076]
[Table 4]

表 4

		実施例					
		19	20	21	22	23	24
組成（モル%）	SiO2	60.0	60.0	60.0	60.0	60.0	60.0
	B2O3	10.0	10.0	10.0	10.0	10.0	10.0
	Al2O3	7.5	10.0	10.0	10.0	10.0	12.0
	MgO	10.0	5.0	10.0	5.0	7.5	8.0
	CaO	0.0	5.0	0.0	0.0	0.0	0.0
	ZnO	0.0	—	—	5.0	0.0	—
	RO	10.0	10.0	10.0	10.0	7.5	8.0
	Li2O	0.0	0.0	0.0	0.0	0.0	0.0
	Na2O	7.5	5.0	5.0	5.0	5.0	5.0
	K2O	5.0	5.0	5.0	5.0	5.0	5.0
	R'2O	12.5	10.0	10.0	10.0	10.0	10.0
	TiO2	0.0	—	—	0.0	2.5	—
	ZrO2	0.0	—	—	0.0	0.0	—
	SiO2+B2O3+Al2O3	77.5	80.0	80.0	80.0	80.0	82.0
	B2O3/Al2O3	1.3	1.0	1.0	1.0	1.0	0.8
	RO+R'2O	22.5	20.0	20.0	20.0	17.5	18.0
	SiO2+B2O3+Al2O3+RO+R'2O	100.0	100.0	100.0	100.0	97.5	100.0
	SiO2+B2O3+Al2O3+R'2O	90.0	90.0	90.0	90.0	90.0	92.0
	SiO2+B2O3+Al2O3+RO+R'2O+TiO2+ZrO2	100.0	100.0	100.0	100.0	100.0	100.0
	合 計	100.0	100.0	100.0	100.0	100.0	100.0
ガラス転移点 Tg[℃]		554	595	583	567	566	598
屈伏点 Td [℃]		619	676	686	672	672	686
熱膨張係数 $\alpha \times 10^{-7}$[/℃]		85	73	77	72	77	66
密度 [g/cm³]		2.409	2.419	2.382	2.448	2.386	2.347
ヤング率 E[GPa]		69.70	70.63	67.26	66.36	66.05	62.00
剛性率G [GPa]		28.54	29.05	27.61	27.17	27.09	—
水中	押し込み荷重 [gF]	1000	1000	1000	1000	1000	1000
	脆さ指標値 B [$\mu m^{-1/2}$]	6.5	6.5	6.1	5.9	5.4	6.0
	ビッカース硬度 Hv [GPa]	5.0	5.3	5.0	4.9	4.8	5.1
	破壊靭性 Kc [MPa/$m^{1/2}$]	0.82	0.83	0.85	0.87	0.95	0.83
	プロバビリティ	100	100	100	95	100	95
乾燥雰囲気 N2	押し込み荷重 [gF]	5980	5980	5980	5980	5980	5980
	脆さ指標値 B [$\mu m^{-1/2}$]	4.2	4.5	4.0	3.9	3.8	4.9
	ビッカース硬度 Hv [GPa]	5.0	5.2	5.0	4.9	4.8	4.9
	破壊靭性 Kc [MPa/$m^{1/2}$]	1.27	1.19	1.29	1.32	1.34	1.01
	プロバビリティ	60	100	100	100	80	100

[0077]
[Table 5]

表 5

		実施例					
		25	26	27	28	29	30
組成（モル%）	SiO2	60.0	60.0	65.0	65.0	65.0	65.0
	B2O3	15.0	20.0	0.0	5.0	5.0	5.0
	Al2O3	10.0	10.0	7.0	2.5	5.0	5.0
	MgO	5.0	0.0	1.0	10.0	10.0	5.0
	CaO	0.0	0.0	1.0	0.0	0.0	5.0
	ZnO	—	—	0.0	0.0	0.0	0.0
	RO	5.0	0.0	2.0	10.0	10.0	10.0
	Li2O	0.0	0.0	10.0	0.0	0.0	0.0
	Na2O	5.0	5.0	10.5	12.5	10.0	10.0
	K2O	5.0	5.0	2.5	5.0	5.0	5.0
	R'2O	10.0	10.0	23.0	17.5	15.0	15.0
	TiO2	—	—	0.0	0.0	0.0	0.0
	ZrO2	—	—	3.0	0.0	—	0.0
	SiO2+B2O3+Al2O3	85.0	90.0	72.0	72.5	75.0	75.0
	B2O3/Al2O3	1.5	2.0	0.0	2.0	1.0	1.0
	RO+R'2O	15.0	10.0	25.0	27.5	25.0	25.0
	SiO2+B2O3+Al2O3+RO+R'2O	100.0	100.0	97.0	100.0	100.0	100.0
	SiO2+B2O3+Al2O3+R'2O	95.0	100.0	95.0	90.0	90.0	90.0
	SiO2+B2O3+Al2O3+RO+R'2O+TiO2+ZrO2	100.0	100.0	100.0	100.0	100.0	100.0
	合 計	100.0	100.0	100.0	100.0	100.0	100.0
ガラス転移点 Tg[℃]		540	488	479	553	558	551
屈伏点 Td [℃]		628	583	551	612.7 626.7	634	619
熱膨張係数 $\alpha \times 10^{-7}$[/℃]		69	71	98	90	85	91
密度[g/cm³]		2.326	2.259	2.535	2.461	2.440	2.483
ヤング率 E[GPa]		81.15	52.00	82.25	73.65	72.10	74.95
剛性率G [GPa]		24.81	—	33.42	30.35	29.73	30.81
水中	押し込み荷重 [gF]	1000	1000	1000	1000	1000	1000
	脆さ指標値 B [$\mu m^{-1/2}$]	6.3	6.2	9.5	7.7	7.6	9.9
	ビッカース硬度 Hv [GPa]	4.8	4.4	—	5.3	5.7	5.4
	破壊靭性 Kc [MPa/$m^{1/2}$]	0.78	0.72	—	0.72	0.73	0.56
	プロバビリティ	100	80	—	100	100	100
乾燥雰囲気 N2	押し込み荷重 [gF]	5980	5980	5980	5980	5980	5980
	脆さ指標値 B [$\mu m^{-1/2}$]	3.8	3.2	5.0	5.8	4.9	5.6
	ビッカース硬度 Hv [GPa]	4.8	4.1	6.0	5.8	5.8	5.4
	破壊靭性 Kc [MPa/$m^{1/2}$]	1.28	1.36	1.18	0.97	1.13	0.99
	プロバビリティ	100	80	100	100	100	100

[0078]
[Table 6]

表 6

		実施例					
		31	32	33	34	35	36
組成（モル%）	SiO2	65.0	65.0	65.0	65.0	65.0	65.0
	B2O3	5.0	5.0	5.0	5.0	5.0	5.0
	Al2O3	5.0	5.0	5.0	5.0	5.0	5.0
	MgO	5.0	5.0	5.0	5.0	5.0	5.0
	CaO	3.0	3.0	5.0	5.0	5.0	5.0
	ZnO	—	—	—	—	—	—
	RO	8.0	8.0	10.0	10.0	10.0	10.0
	Li2O	2.0	0.0	2.0	2.0	2.0	4.0
	Na2O	10.0	12.0	11.0	9.0	7.0	9.0
	K2O	5.0	5.0	2.0	4.0	6.0	2.0
	R'2O	17.0	17.0	15.0	15.0	15.0	15.0
	TiO2	0.0	0.0	0.0	0.0	0.0	0.0
	ZrO2	—	—	—	—	—	—
	SiO2+B2O3+Al2O3	75.0	75.0	75.0	75.0	75.0	75.0
	B2O3/Al2O3	1.0	1.0	1.0	1.0	1.0	1.0
	RO+R'2O	25.0	25.0	25.0	25.0	25.0	25.0
	SiO2+B2O3+Al2O3+RO+R'2O	100.0	100.0	100.0	100.0	100.0	100.0
	SiO2+B2O3+Al2O3+R'2O	92.0	92.0	90.0	90.0	90.0	90.0
	SiO2+B2O3+Al2O3+RO +R'2O+TiO2+ZrO2	100.0	100.0	100.0	100.0	100.0	100.0
	合 計	100.0	100.0	100.0	100.0	100.0	100.0
ガラス転移点 Tg[℃]		511	540	524	526	523	507
屈伏点 Td [℃]		581	608	599	593	595	572
熱膨張係数 $\alpha \times 10^{-7}$[/℃]		92	95	83	85	87	106
密度 [g/cm³]		2.473	2.477	2.485	2.482	2.477	2.478
ヤング率 E[GPa]		76.71	74.00	78.97	78.28	77.13	80.71
剛性率G [GPa]		31.62	30.48	32.50	32.21	31.74	33.26
水中	押し込み荷重 [gF]	1000	1000	1000	1000	1000	1000
	脆さ指標値 B [$\mu m^{-1/2}$]	9.9	9.8	9.8	10.0	10.6	10.0
	ビッカース硬度 Hv [GPa]	5.8	5.3	5.7	5.8	5.8	5.8
	破壊靭性 Kc [MPa/$m^{1/2}$]	0.58	0.56	0.60	0.58	0.55	0.59
	プロバビリティ	100	100	100	100	100	100
乾燥雰囲気 N2	押し込み荷重 [gF]	5980	5980	5980	5980	5980	5980
	脆さ指標値 B [$\mu m^{-1/2}$]	5.0	4.8	5.4	5.6	5.5	5.1
	ビッカース硬度 Hv [GPa]	5.6	5.1	5.5	5.7	5.7	5.6
	破壊靭性 Ko [MPa/$m^{1/2}$]	1.13	1.14	1.08	1.04	1.04	1.15
	プロバビリティ	100	100	100	100	100	100

[0079]
[Table 7]

表 7

		実施例					
		37	38	39	40	41	42
組成（モル%）	SiO2	65.0	65.0	65.0	65.0	65.0	65.0
	B2O3	5.0	5.0	5.0	5.0	5.0	5.0
	Al2O3	5.0	5.0	5.0	5.0	5.0	5.0
	MgO	5.0	5.0	5.0	5.0	5.0	5.0
	CaO	5.0	5.0	5.0	5.0	5.0	5.0
	ZnO	—	—	—	—	—	0.0
	RO	10.0	10.0	10.0	10.0	10.0	10.0
	Li2O	4.0	4.0	6.0	6.0	6.0	8.0
	Na2O	7.0	5.0	7.0	5.0	3.0	5.0
	K2O	4.0	6.0	2.0	4.0	6.0	2.0
	R'2O	15.0	15.0	15.0	15.0	15.0	15.0
	TiO2	0.0	0.0	0.0	0.0	0.0	0.0
	ZrO2	—	—	—	—	—	0.0
	SiO2+B2O3+Al2O3	75.0	75.0	75.0	75.0	75.0	75.0
	B2O3/Al2O3	1.0	1.0	1.0	1.0	1.0	1.0
	RO+R'2O	25.0	25.0	25.0	25.0	25.0	25.0
	SiO2+B2O3+Al2O3+RO+R'2O	100.0	100.0	100.0	100.0	100.0	100.0
	SiO2+B2O3+Al2O3+R'2O	90.0	90.0	90.0	90.0	90.0	90.0
	SiO2+B2O3+Al2O3+RO +R'2O+TiO2+ZrO2	100.0	100.0	100.0	100.0	100.0	100.0
	合 計	100.0	100.0	100.0	100.0	100.0	100.0
ガラス転移点 Tg[℃]		510	508	500	501	501	488
屈伏点 Td [℃]		579	579	566	568	571	552
熱膨張係数 $\alpha \times 10^{-7}$[/℃]		85	115	78	81	80	78
密度 [g/cm³]		2.474	2.469	2.470	2.465	2.460	2.464
ヤング率 E[GPa]		79.81	78.63	82.37	81.18	79.50	83.61
剛性率G [GPa]		32.88	32.38	33.93	33.44	32.76	34.44
水中	押し込み荷重 [gF]	1000	1000	1000	1000	1000	1000
	脆さ指標値 B [$\mu m^{-1/2}$]	10.1	10.5	10.0	9.9	10.4	9.9
	ビッカース硬度 Hv [GPa]	5.9	5.8	5.9	5.9	5.9	6.1
	破壊靭性 Kc [MPa/$m^{1/2}$]	0.58	0.56	0.60	0.60	0.57	0.61
	プロバビリティ	100	100	100	100	100	100
乾燥雰囲気 N2	押し込み荷重 [gF]	5980	5980	5980	5980	5980	5980
	脆さ指標値 B [$\mu m^{-1/2}$]	5.6	5.1	4.9	5.0	5.2	4.7
	ビッカース硬度 Hv [GPa]	5.7	5.5	5.6	5.6	5.6	5.5
	破壊靭性 Kc [MPa/$m^{1/2}$]	1.04	1.13	1.13	1.17	1.11	1.25
	プロバビリティ	100	100	100	100	100	100

[0080]
[Table 8]

表 8

		実施例					
		43	44	45	46	47	48
組成（モル%）	SiO2	65.0	65.0	65.0	65.0	65.0	65.0
	B2O3	5.0	5.0	5.0	5.0	5.0	5.0
	Al2O3	5.0	5.0	5.0	5.0	5.0	7.0
	MgO	5.0	5.0	5.0	5.0	5.0	5.0
	CaO	5.0	5.0	5.0	0.0	0.0	3.0
	ZnO	0.0	0.0	0.0	0.0	0.0	—
	RO	10.0	10.0	10.0	5.0	5.0	8.0
	Li2O	8.0	8.0	0.0	8.0	2.0	0.0
	Na2O	3.0	1.0	11.0	10.0	10.0	10.0
	K2O	4.0	6.0	4.0	2.0	5.0	5.0
	R'2O	15.0	15.0	15.0	20.0	17.0	15.0
	TiO2	0.0	0.0	0.0	0.0	0.0	0.0
	ZrO2	0.0	—	0.0	0.0	3.0	—
	SiO2+B2O3+Al2O3	75.0	75.0	75.0	75.0	75.0	77.0
	B2O3/Al2O3	1.0	1.0	1.0	1.0	1.0	0.7
	RO+R'2O	25.0	25.0	25.0	25.0	22.0	23.0
	SiO2+B2O3+Al2O3+RO+R'2O	100.0	100.0	100.0	100.0	97.0	100.0
	SiO2+B2O3+Al2O3+R'2O	90.0	90.0	90.0	95.0	92.0	92.0
	SiO2+B2O3+Al2O3+RO+R'2O+TiO2+ZrO2	100.0	100.0	100.0	100.0	100.0	100.0
	合 計	100.0	100.0	100.0	100.0	100.0	100.0
ガラス転移点 Tg[℃]		494	504	552	474	533	538
屈伏点 Td [℃]		561	577	622	536	615	596
熱膨張係数 $\alpha \times 10^{-7}$[/℃]		81	73	89	91	87	122
密度 [g/cm³]		2.458	2.446	2.485	2.449	2.525	2.462
ヤング率 E[GPa]		82.10	79.04	75.27	79.92	77.29	71.94
剛性率G [GPa]		33.82	32.64	30.96	32.45	31.61	29.58
水中	押し込み荷重 [gF]	1000	1000	1000	1000	1000	1000
	脆さ指標値 B [$\mu m^{-1/2}$]	9.8	9.9	9.9	9.5	9.0	8.5
	ビッカース硬度 Hv [GPa]	5.9	5.7	5.8	—	—	5.1
	破壊靭性 Kc [MPa/$m^{1/2}$]	0.61	0.59	0.58	—	—	0.63
	プロバビリティ	100	100	100	—	—	100
乾燥雰囲気 N2	押し込み荷重 [gF]	5980	5980	5980	5980	5980	5980
	脆さ指標値 B [$\mu m^{-1/2}$]	4.7	4.8	5.7	4.6	4.3	5.1
	ビッカース硬度 Hv [GPa]	5.6	5.4	5.5	5.6	5.5	5.2
	破壊靭性 Kc [MPa/$m^{1/2}$]	1.25	1.19	0.99	1.27	1.30	1.06
	プロバビリティ	100	100	100	100	100	100

[0081]
[Table 9]

表 9

		実施例						
		49	50	51	52	53	54	55
組成（モル%）	SiO2	65.0	65.0	65.0	65.0	65.4	65.4	65.4
	B2O3	5.0	5.0	7.5	10.0	0.0	0.0	0.0
	Al2O3	7.5	10.0	2.5	0.0	8.6	8.6	8.6
	MgO	10.0	10.0	5.0	5.0	0.0	0.0	0.0
	CaO	0.0	0.0	5.0	5.0	0.0	0.0	0.0
	ZnO	0.0	0.0	—	—	0.0	0.0	0.0
	RO	10.0	10.0	10.0	10.0	0.0	0.0	0.0
	Li2O	0.0	0.0	0.0	0.0	12.5	7.5	0.0
	Na2O	7.5	5.0	10.0	10.0	10.5	10.5	13.0
	K2O	5.0	5.0	5.0	5.0	0.0	5.0	10.0
	R'2O	12.5	10.0	15.0	15.0	23.0	23.0	23.0
	TiO2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	ZrO2	—	—	—	—	3.0	3.0	3.0
	SiO2+B2O3+Al2O3	77.5	80.0	75.0	75.0	74.0	74.0	74.0
	B2O3/Al2O3	0.7	0.5	3.0	—	0.0	0.0	0.0
	RO+R'2O	22.5	20.0	25.0	25.0	23.0	23.0	23.0
	SiO2+B2O3+Al2O3+RO+R'2O	100.0	100.0	100.0	100.0	97.0	97.0	97.0
	SiO2+B2O3+Al2O3+R'2O	90.0	90.0	90.0	90.0	97.0	97.0	97.0
	SiO2+B2O3+Al2O3+RO +R'2O+TiO2+ZrO2	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	合 計	100.0	100.0	100.0	100.0	100.0	100.0	100.0
ガラス転移点 Tg[℃]		577	631	557	559	498	491	534
屈伏点 Td [℃]		658	752	622	623	564	568	629
熱膨張係数 $\alpha\times10^{-7}$[/℃]		76	70	87	89	89	116	113
密度 [g/cm³]		2.419	2.399	2.486	2.493	2.511	2.523	2.537
ヤング率 E[GPa]		71.46	70.77	76.10	78.41	84.13	79.70	71.31
剛性率 G [GPa]		29.51	29.49	31.35	32.37	34.71	32.62	29.30
水中	押し込み荷重 [gF]	1000	1000	1000	1000	1000	1000	1000
	脆さ指標値 B [$\mu m^{-1/2}$]	8.4	7.1	10.4	13.2	7.8	8.4	7.9
	ビッカース硬度 Hv [GPa]	5.6	5.1	5.4	5.9	5.6	5.7	5.4
	破壊靭性 Kc [MPa/$m^{1/2}$]	0.96	0.76	0.54	0.44	0.77	0.70	0.69
	プロバビリティ	100	100	100	100	100	100	100
乾燥雰囲気 N2	押し込み荷重 [gF]	5980	5980	5980	5980	5980	5980	5980
	脆さ保存性 B[$\mu m^{-1/2}$]	5.2	5.3	4.9	5.5	4.3	5.0	5.2
	ビッカース硬度 Hv [GPa]	5.6	5.2	5.2	5.5	5.4	5.5	4.9
	破壊靭性 Kc [MPa/$m^{1/2}$]	1.05	1.01	1.13	1.05	1.37	1.16	1.02
	プロバビリティ	100	100	100	100	100	100	100

[0082]
[Table 10]

表 10

		実施例					
		56	57	58	59	60	61
組成（モル%）	SiO2	48.0	53.2	57.0	59.0	59.0	59.0
	B2O3	16.0	14.4	9.5	9.0	9.5	10.5
	Al2O3	16.0	14.4	9.5	9.0	9.5	10.5
	MgO	0.0	0.0	2.0	3.0	2.0	0.0
	CaO	0.0	0.0	0.0	0.0	0.0	0.0
	ZnO	0.0	0.0	0.0	0.0	0.0	0.0
	RO	0.0	0.0	2.0	3.0	2.0	0.0
	Li2O	10.0	10.0	9.0	10.0	9.0	10.0
	Na2O	8.0	6.0	9.0	10.0	9.0	5.0
	K2O	2.0	2.0	2.0	0.0	2.0	5.0
	R'2O	20.0	18.0	20.0	20.0	20.0	20.0
	TiO2	0.0	0.0	0.0	0.0	0.0	0.0
	ZrO2	0.0	0.0	2.0	0.0	0.0	0.0
	SiO2+B2O3+Al2O3	80.0	82.0	76.0	77.0	78.0	80.0
	B2O3/Al2O3	1.0	1.0	1.0	1.0	1.0	1.0
	RO+R'2O	20.0	18.0	22.0	23.0	22.0	20.0
	SiO2+B2O3+Al2O3+RO+R'2O	100.0	100.0	98.0	100.0	100.0	100.0
	SiO2+B2O3+Al2O3+R'2O	100.0	100.0	86.0	97.0	98.0	100.0
	SiO2+B2O3+Al2O3+RO +R'2O+TiO2+ZrO2	100.0	100.0	100.0	100.0	100.0	100.0
	合 計	100.0	100.0	100.0	100.0	100.0	100.0
ガラス転移点 Tg[℃]		475	483	484	483	476	473
屈伏点 Td [℃]		525	539	543	534	530	529
熱膨張係数 $\alpha \times 10^{-7}$[/℃]		90	77	89	84	87	84
密度 [g/cm³]		2.382	2.359	2.492	2.456	2.444	2.415
ヤング率 E[GPa]		72.62	71.84	81.35	83.13	80.45	77.88
剛性率 G [GPa]		29.16	28.96	32.96	33.70	32.73	31.71
乾燥雰囲気 N2	押し込み荷重 [gF]	6952	6952	6952	6952	6952	6952
	脆さ保存性 B[$\mu m^{-1/2}$]	3.5	3.1	3.9	3.8	3.7	3.8
	ビッカース硬度 Hv [GPa]	5.2	5.0	5.8	5.8	5.7	5.6
	破壊靭性 Kc [MPa/$m^{1/2}$]	1.54	1.71	1.53	1.57	1.56	1.51
	プロパビリティ	20	60	100	100	100	80

[0083]
[Table 11]

表 11

		実施例					
		62	63	64	65	66	67
組成（モル%）	SiO2	59.0	60.0	60.0	60.0	60.0	61.0
	B2O3	10.5	0.0	5.0	7.5	9.0	5.0
	Al2O3	10.5	15.0	15.0	7.5	9.0	12.0
	MgO	0.0	5.0	0.0	5.0	0.0	5.0
	CaO	0.0	0.0	0.0	0.0	0.0	0.0
	ZnO	0.0	0.0	0.0	0.0	0.0	0.0
	RO	0.0	5.0	0.0	5.0	0.0	5.0
	Li2O	10.0	9.0	9.0	10.0	9.0	10.0
	Na2O	10.0	9.0	9.0	5.0	9.0	5.0
	K2O	0.0	2.0	2.0	5.0	2.0	2.0
	R'2O	20.0	20.0	20.0	20.0	20.0	17.0
	TiO2	0.0	0.0	0.0	0.0	0.0	0.0
	ZrO2	0.0	0.0	0.0	0.0	2.0	0.0
	SiO2+B2O3+Al2O3	80.0	75.0	80.0	75.0	78.0	78.0
	B2O3/Al2O3	1.0	0.0	0.3	1.0	1.0	0.4
	RO+R'2O	20.0	25.0	20.0	25.0	20.0	22.0
	SiO2+B2O3+Al2O3+RO+R'2O	100.0	100.0	100.0	100.0	98.0	100.0
	SiO2+B2O3+Al2O3+R'2O	100.0	95.0	100.0	95.0	98.0	95.0
	SiO2+B2O3+Al2O3+RO +R'2O+TiO2+ZrO2	100.0	100.0	100.0	100.0	100.0	100.0
	合 計	100.0	100.0	100.0	100.0	100.0	100.0
ガラス転移点 Tg[℃]		485	530	491	464	487	495
屈伏点 Td [℃]		536	610	560	535	545	564
熱膨張係数 $\alpha \times 10^{-7}$[/℃]		82	93	88	91	87	78
密度 [g/cm³]		2.420	2.464	2.428	2.428	2.48	2.422
ヤング率 E[GPa]		80.13	82.79	78.75	79.23	81.53	80.56
剛性率 G [GPa]		32.65	33.71	32.05	32.38	33.22	32.77
乾燥雰囲気 N2	押し込み荷重 [gF]	6952	6952	6952	6952	6952	6952
	能さ保存性 B[$\mu m^{-1/3}$]	3.5	4.2	4.1	4.2	3.9	3.9
	ビッカース硬度 Hv [GPa]	5.5	5.7	5.4	5.8	5.8	5.5
	破壊靭性 Kc [MPa/$m^{1/2}$]	1.65	—	—	1.40	1.50	—
	プロバビリティ	75	80	100	60	80	100

[0084]
[Table 12]

表 12

		実施例					
		68	69	70	71	72	73
組成（モル%）	SiO2	61.0	62.0	63.0	63.0	63.0	65.0
	B2O3	9.5	7.0	7.5	8.5	8.5	2.5
	Al2O3	9.5	7.0	7.5	8.5	8.5	10.5
	MgO	0.0	2.0	2.0	0.0	0.0	5.0
	CaO	0.0	—	0.0	0.0	0.0	0.0
	ZnO	0.0	—	0.0	0.0	0.0	0.0
	RO	0.0	2.0	2.0	0.0	0.0	5.0
	Li2O	10.0	9.0	9.0	10.0	9.0	10.0
	Na2O	10.0	9.0	9.0	10.0	9.0	5.0
	K2O	0.0	2.0	2.0	0.0	2.0	2.0
	R'2O	20.0	20.0	20.0	20.0	20.0	17.0
	TiO2	0.0	—	0.0	0.0	0.0	0.0
	ZrO2	0.0	2.0	0.0	0.0	0.0	0.0
	SiO2+B2O3+Al2O3	80.0	76.0	78.0	80.0	80.0	78.0
	B2O3/Al2O3	1.0	1.0	1.0	1.0	1.0	0.2
	RO+R'2O	20.0	22.0	22.0	20.0	20.0	22.0
	SiO2+B2O3+Al2O3+RO+R'2O	100.0	98.0	100.0	100.0	100.0	100.0
	SiO2+B2O3+Al2O3+R'2O	100.0	96.0	98.0	100.0	100.0	95.0
	SiO2+B2O3+Al2O3+RO +R'2O+TiO2+ZrO2	100.0	100.0	100.0	100.0	100.0	100.0
	合 計	100.0	100.0	100.0	100.0	100.0	100.0
ガラス転移点 Tg[℃]		483	480	471	480	479	493
屈伏点 Td [℃]		535	540	528	533	537	568
熱膨張係数 $\alpha \times 10^{-7}$[/℃]		85	86	89	84	89	80
密度 [g/cm³]		2.427	2.450	2.448	2.431	2.431	2.421
ヤング率 E[GPa]		81.00	83.00	80.96	81.57	79.91	80.67
剛性率 G [GPa]		33.06	—	33.00	33.37	32.71	33.09
乾燥雰囲気 N2	押し込み荷重 [gF]	6952	6952	6952	6952	6952	6952
	脆さ保存性 B[$\mu m^{-1/3}$]	3.7	4.0	4.1	3.9	3.8	4.1
	ビッカース硬度 Hv [GPa]	5.8	—	5.7	5.5	5.5	5.7
	破壊靭性 Kc [MPa/$m^{1/2}$]	1.58	—	1.44	1.51	1.52	—
	プロバビリティ	40	—	100	100	100	100

[0085]
[Table 13]

表 13

		実施例			
		74	75	76	77
組成（モル%）	SiO2	65.0	65.0	65.0	65.0
	B2O3	5.0	7.5	7.5	7.5
	Al2O3	5.0	7.5	7.5	7.5
	MgO	0.0	0.0	0.0	0.0
	CaO	0.0	0.0	0.0	0.0
	ZnO	0.0	0.0	0.0	0.0
	RO	0.0	0.0	0.0	0.0
	Li2O	10.0	5.0	10.0	10.0
	Na2O	10.0	10.0	5.0	7.5
	K2O	5.0	5.0	5.0	2.5
	R'2O	25.0	20.0	20.0	20.0
	TiO2	0.0	0.0	0.0	0.0
	ZrO2	0.0	0.0	0.0	0.0
	SiO2+B2O3+Al2O3	75.0	80.0	80.0	80.0
	B2O3/Al2O3	1.0	1.0	1.0	1.0
	RO+R'2O	25.0	20.0	20.0	20.0
	SiO2+B2O3+Al2O3+RO+R'2O	100.0	100.0	100.0	100.0
	SiO2+B2O3+Al2O3+R'2O	100.0	100.0	100.0	100.0
	SiO2+B2O3+Al2O3+RO +R'2O+TiO2+ZrO2	100.0	100.0	100.0	100.0
	合 計	100.0	100.0	100.0	100.0
ガラス転移点 Tg[℃]		451	482	475	472
屈伏点 Td [℃]		510	541	538	529
熱膨張係数 $\alpha \times 10^{-7}$[/℃]		107	95	85	84
密度 [g/cm³]		2.453	2.452	2.420	2.429
ヤング率 E[GPa]		77.98	77.81	78.83	80.62
剛性率 G [GPa]		31.79	31.87	32.27	33.01
乾燥雰囲気 N2	押し込み荷重 [gF]	6952	6952	6952	6952
	脆さ保存性 B[$\mu m^{-1/2}$]	4.0	4.3	4.1	3.9
	ビッカース硬度 Hv [GPa]	5.4	5.4	5.7	5.6
	破壊靭性 Kc [MPa/$m^{1/2}$]	1.42	1.31	1.42	1.51
	プロバビリティ	100	100	100	80

[0086]
[Table 14]

表 14

		実施例			
		78	79	80	81
組成（モル%）	SiO2	65.0	65.0	65.0	65.0
	B2O3	7.5	7.5	7.5	10.0
	Al2O3	7.5	7.5	7.5	0.0
	MgO	0.0	0.0	0.0	5.0
	CaO	0.0	0.0	0.0	0.0
	ZnO	0.0	0.0	0.0	0.0
	RO	0.0	0.0	0.0	5.0
	Li2O	10.0	10.0	9.0	5.0
	Na2O	10.0	10.0	9.0	10.0
	K2O	0.0	0.0	2.0	5.0
	R'2O	20.0	20.0	20.0	20.0
	TiO2	0.0	0.0	0.0	0.0
	ZrO2	0.0	0.0	0.0	0.0
	SiO2+B2O3+Al2O3	80.0	80.0	80.0	75.0
	B2O3/Al2O3	1.0	1.0	1.0	—
	RO+R'2O	20.0	20.0	20.0	25.0
	SiO2+B2O3+Al2O3+RO+R'2O	100.0	100.0	100.0	100.0
	SiO2+B2O3+Al2O3+R'2O	100.0	100.0	100.0	95.0
	SiO2+B2O3+Al2O3+RO +R'2O+TiO2+ZrO2	100.0	100.0	100.0	100.0
	合 計	100.0	100.0	100.0	100.0
ガラス転移点 Tg[℃]		483	478	477	484
屈伏点 Td [℃]		544	533	533	541
熱膨張係数 $\alpha \times 10^{-7}$[/℃]		83	83	85	88
密度 [g/cm³]		2.440	2.431	2.434	2.477
ヤング率 E[GPa]		82.07	82.00	80.81	80.64
剛性率 G [GPa]		33.58	33.65	33.15	33.02
乾燥雰囲気 N2	押し込み荷重 [gF]	1000	1000	1000	1000
	脆さ保存性 B[$\mu m^{-1/7}$]	3.9	3.8	3.9	4.2
	ビッカース硬度 Hv [GPa]	5.6	5.6	5.7	5.7
	破壊靭性 Kc [MPa/$m^{1/2}$]	1.52	1.53	1.48	1.39
	プロバビリティ	80	100	100	100

[0087] About the glass indicated by the example 1 of a comparison - 3 JP,10-158028,A, the physical properties were shown in Table 15.
[0088]
[Table 15]

表 15

		比較例 1	比較例 2	比較例 3
組成（モル%）	SiO2	69.28	69.94	68.94
	B2O3	—	—	—
	Al2O3	2.5	2.51	4.24
	MgO	6.97	6.96	5.77
	CaO	7.97	8	8.28
	SrO	—	0.24	1.81
	Li2O	—	—	—
	Na2O	1.96	4.93	1.46
	K2O	9.56	6.75	9.25
	TiO2	—	—	—
	ZrO2	1.76	0.66	0.26
	合 計	100.0	100.0	100.0
ガラス転移点 Tg[℃]		657	623	658
屈伏点 Td [℃]		780	710	732
熱膨張係数 $\alpha \times 10^{-7}$[/℃]		86.8	85.8	82.8
密度 [g/cm^3]		2.52	2.49	2.51
ヤング率 E[GPa]		80.5	80.3	81.5
押し込み荷重 [gF]		1000	1000	1000
脆さ指標値 B [$\mu m^{-1/2}$]		7.2	7.2	7.1
ビッカース硬度 Hv [GPa]		6.1	6.1	6.2
破壊靭性 Kc [MPa/m$^{1/2}$]		0.90	0.91	1.05

[0089] The glass obtained in the example 82 examples 1-81 is used, and it is (1) rough wrapping process (rough grinding process), (2) By performing a configuration processing process, (3) energy wrapping process (energy grinding operation), (4) end-face mirror plane processing process, the (5) 1st polish processes, the (6) 2nd polish processes, (7) inspection processes, and (8) magnetic-disk production process one by one, the glass substrate for information record media was produced, and the magnetic disk was manufactured further. In addition, pure water was used for the water of the polish liquid used for the polish equipment from the above-mentioned (4) end-face mirror plane processing process to the (6) 2nd polish processes.

[0090] (1) Rough wrapping ** obtained diameter 96mmphi and a disc-like glass substrate with a thickness of 1.5mm from melting glass with the direct press using a punch, female mold, and a mold more nearly first. In addition, in this case, in addition to a direct press, it may start with a grinding stone from the sheet glass formed with the down draw method or the float glass process, and a disc-like glass substrate may be obtained.

[0091] Subsequently, the wrapping process was performed in order to raise dimensional accuracy and configuration precision to a glass substrate. This wrapping process was performed using the abrasive grain of grain-size #400 using double-sided wrapping equipment. Both sides of the glass substrate contained in the carrier were wrapped at the profile irregularity of 0-1 micrometer, and about 6 micrometers (Rmax) of surface roughness by using the alumina abrasive grain of grain-size #400 first, specifically setting a load as about 980N, and rotating an internal gear with Sun Geer.

[0092] (2) While vacating the hole for the central part of a glass substrate using the grinding stone of the shape of a configuration processing process, next a cylinder, after carrying out grinding of a periphery end face and setting a diameter to 95mmphi, predetermined beveling processing was performed to the periphery end face and the inner circumference end face. The surface roughness of the glass substrate end face in this case was about 4 micrometers in Rmax.

[0093] (3) By changing an energy wrapping process, next the grain size of an abrasive grain into #1000, and wrapping a glass substrate front face, it was set as about 2 micrometers by Rmax, and surface roughness was set to about 0.2 micrometers by Ra. Sequential immersion of the glass substrate which finished the above-mentioned wrapping process was carried out at each washing tub (ultrasonic impression) of neutral detergent and water, and ultrasonic cleaning was performed.

[0094] (4) More nearly subsequently, rotating a glass substrate, by brushing, it ground to 1 micrometer by Rmax, and end-face mirror plane ****** ground the granularity of the front face of the end face (inner circumference, periphery) of a glass substrate to about 0.3 micrometers by Ra. And backwashing by water of the front face of the glass substrate which finished the above-mentioned end-face mirror plane processing was carried out.

[0095] (5) In order to remove the blemish and distortion which remained at the 1st polish process, next the wrapping process mentioned above, the 1st polish process was performed using double-sided polish equipment. In double-sided polish equipment, the glass substrate held with the carrier is stuck between the vertical surface

plates with which the scouring pad was stuck, this carrier is meshed to Sun Geer and an internal gear, and the above-mentioned glass substrate is compressed with a vertical surface plate. Then, by supplying polish liquid between a scouring pad and the polished surface of a glass substrate, and making it rotate, while a glass substrate rotates on a surface plate, it revolves around the sun, and polish processing of both sides is carried out at coincidence. Hereafter, the same equipment was used as double-sided polish equipment used in the example.

[0096] Specifically, the polish process was carried out, using a hard polisher (hard urethane foam) as a polisher. Polish conditions were used as cerium oxide (mean particle diameter of 1.3 micrometers) + pure water as polish liquid, and were made into load:9.8mN/mm2, and polish time amount:15 minutes. To neutral detergent, pure water, pure water, isopropyl alcohol (IPA), and each washing tub of IPA (steam seasoning), sequential immersion was carried out, and the glass substrate which finished the above-mentioned 1st polish process was cleaned ultrasonically, and was dried to them.

[0097] (6) the 2nd polish process -- using the double-sided polish equipment same type as what was used at the 1st polish process next, the polisher was changed into the elasticity polisher (suede putt), and the 2nd polish process was carried out. This 2nd polish process aims at reducing surface roughness Ra to about 1.0-0.3 micrometers or less, for example, maintaining the flat front face obtained at the 1st polish process mentioned above. Polish conditions were used as cerium oxide (mean particle diameter of 0.8 micrometers) + pure water as polish liquid, and made load:9.8mN/mm2 and polish time amount 5 minutes. To neutral detergent, pure water, pure water, and each washing tub of IPA and IPA (steam seasoning), sequential immersion was carried out, and the glass substrate which finished the above-mentioned 2nd polish process was cleaned ultrasonically, and was dried to them. Although the glass substrate of this example did not have a chemical-strengthening layer, a glass substrate did not destroy it at the time of handling of the inside of said polish process, a process, and a process.

[0098] (7) The close examination using the visual inspection on an inspection process, next the front face of a glass substrate which finished the above-mentioned desiccation, and reflection, dispersion and transparency of light was carried out. Consequently, defects, such as a blemish, were not discovered on a glass substrate front face. Moreover, when the surface roughness on the front face of main of a glass substrate pass the above-mentioned process was measured with the atomic force microscope (AFM), the glass substrate for magnetic disks with Rmax=2.13nm, Ra=0.20nm, and an overly smooth front face was obtained.

[0099] (8) The inline-type sputtering system was used for both the main front face of the glass substrate for magnetic disks pass the magnetic-disk production process above-mentioned process, sequential membrane formation of a NiAl seed layer, a CrV substrate layer, a CoPtCrB magnetic layer, and the hydrogenation carbon protective layer was carried out, the perfluoro polyether lubricating layer was further formed with the dip method, and the magnetic disk was obtained. About the obtained magnetic disk, when the touch-down height test was carried out, the touch-down height showed 5nm and a good value. Moreover, even if it performed the load unload trial (100,000 times), a head did not crash.

[0100] The magnetic disk was manufactured like the example 82 except having performed the following chemical-strengthening process between the (6) aforementioned 2nd polish processes in example 83 example 82, and the inspection process of the above (7). The chemical-strengthening process prepared the chemical-strengthening liquid containing the mixture of a potassium nitrate and a sodium nitrate, heated this chemical-strengthening solution at 380 degrees C, was immersed in the glass substrate [finishing / above-mentioned washing and desiccation] for about 4 hours, performed chemical-strengthening processing, to a sulfuric acid, neutral detergent, pure water, pure water, and each washing tub of IPA and IPA (steam seasoning), it carried out sequential immersion, cleaned ultrasonically the glass substrate which finished the chemical strengthening, and dried it to them.

[0101] When the 0.4mm flake was cut down and it measured about the obtained glass substrate using the polarization microscope, it was checked that the chemical-strengthening layer is formed. A glass substrate did not destroy the glass substrate of this example at the time of handling of the inside of said polish process, a process, and a process. About the obtained magnetic disk, when the touch-down height test was carried out, the touch-down height showed 5nm and a good value. Moreover, even if it performed the load unload trial (100,000 times), a head did not crash.

[Translation done.]

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(54)【発明の名称】情報記録媒体用ガラス基板及びそれを用いた磁気情報記録媒体

(57)【要約】

【課題】　耐擦傷性に優れ、かつ軽量で、破壊靭性の大きな情報記録媒体用基板およびそれを用いた磁気情報記録媒体を提供する。

【解決手段】　水中における脆さ指標値が１２$\mu m^{-1/2}$以下および／または露点が－５℃以下の雰囲気における脆さ指標値が７$\mu m^{-1/2}$以下である情報記録媒体用ガラス基板、あるいはモル％で、SiO_2　４０～７５％、B_2O_3および／またはAl_2O_3　２～４５％およびR'_2O（R'はＬｉ、ＮａおよびＫの中から選ばれる少なくとも１種）０～４０％を含み、かつSiO_2とB_2O_3とAl_2O_3とR'_2Oとの合計含有量が９０％以上であるガラスからなる情報記録媒体用ガラス基板、および前記ガラス基板上に、少なくとも磁気記録層を有する磁気情報記録媒体である。

【特許請求の範囲】

【請求項１】　水中における脆さ指標値が１２$\mu m^{-1/2}$以下であることを特徴とする情報記録媒体用ガラス基板。

【請求項２】　露点が－５℃以下の雰囲気における脆さ指標値が７$\mu m^{-1/2}$以下であることを特徴とする情報記録媒体用ガラス基板。

【請求項３】　水中における脆さ指標値が１２$\mu m^{-1/2}$以下であり、かつ露点が－５℃以下の雰囲気における脆さ指標値が７$\mu m^{-1/2}$以下であることを特徴とする情報記録媒体用ガラス基板。

【請求項４】　モル％で、SiO_2と、B_2O_3および／またはAl_2O_3とを合計量で６５％より多く含むと共に、ＲＯ（ＲはＭｇ、Ｃａ、Ｚｎ、ＳｒおよびＢａの中から選ばれる少なくとも１種）０～２０％、R'_2O（Ｒ'はＬｉ、ＮａおよびＫの中から選ばれる少なくとも１種）０～２８％、TiO_2　０～１０％およびZrO_2　０～１０％を含み、かつ上記成分の合計含有量が９５％以上であるガラスからなる請求項１、２または３に記載の情報記録媒体用ガラス基板。

【請求項５】　モル％で、SiO_2　４０～７５％、B_2O_3および／またはAl_2O_3　２～４５％およびR'_2O（Ｒ'はＬｉ、ＮａおよびＫの中から選ばれる少なくとも１種）０～４０％を含み、かつSiO_2とB_2O_3とAl_2O_3とR'_2Oとの合計含有量が９０％以上であるガラスからなることを特徴とする情報記録媒体用ガラス基板。

【請求項６】　水中における脆さ指標値が１２$\mu m^{-1/2}$以下である請求項５に記載の情報記録媒体用ガラス基板。

【請求項７】　露点が－５℃以下の雰囲気における脆さ指標値が７$\mu m^{-1/2}$以下である請求項５または６に記載の情報記録媒体用ガラス基板。

【請求項８】　ヤング率が７０ＧＰａ以上である請求項１ないし７のいずれか１項に記載の情報記録媒体用ガラス基板。

【請求項９】　剛性率が２０ＧＰａ以上である請求項１ないし８のいずれか１項に記載の情報記録媒体用ガラス基板。

【請求項１０】　液相温度以上の温度領域において、粘度が１Ｐａ・ｓ以上である領域を有するガラスからなる請求項１ないし９のいずれか１項に記載の情報記録媒体用ガラス基板。

【請求項１１】　熱膨張係数が、１００～３００℃の温度において、60×10^{-7}／℃以上であるガラスからなる請求項１ないし１０のいずれか１項に記載の情報記録媒体用ガラス基板。

【請求項１２】　化学強化層を有さない請求項１ないし１１のいずれか１項に記載の情報記録媒体用ガラス基板。

【請求項１３】　化学強化層を有する請求項１ないし１１のいずれか１項に記載の情報記録媒体用ガラス基板。

【請求項１４】　請求項１ないし１３のいずれか１項に記載の情報記録媒体用ガラス基板上に、少なくとも磁気記録層を有することを特徴とする磁気情報記録媒体。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、情報記録媒体用ガラス基板およびそれを用いた磁気情報記録媒体に関する。さらに詳しくは、本発明は、耐擦傷性に優れ、かつ軽量で、破壊靭性の大きな情報記録媒体用ガラス基板、および該情報記録媒体用ガラス基板を用いた、ハードディスクに代表される磁気情報記録媒体に関するものである。

【０００２】

【従来の技術】従来、磁気情報記録媒体用基板材料としては、アルミニウム、ガラス、セラミックスなどが用いられてきた。現在、サイズや用途に応じて主にアルミニウムとガラスが実用化されている。その中でガラス基板は、表面欠陥が少なく、平滑性や表面硬度が優れているため、その使用範囲が年々拡大してきている。磁気情報記録媒体用基板として用いられるガラスとしては、イオン交換法による化学強化ガラス、結晶化ガラスなどが知られている。化学強化ガラスとしては、例えば、特開平１－２３９０３６号公報には、重量％表示で、SiO_2：５０～６５％、Al_2O_3：０．５～１４％、R_2O（但しＲはアルカリ金属イオン）：１０～３２％、ＺｎＯ：１～１５％、B_2O_3：１．１～１４％を含むガラスをアルカリイオンによるイオン交換法によってガラス基板の表面に圧縮応力層を形成し化学強化された磁気ディスク用ガラス基板が開示されている。また、結晶化ガラスとしては、例えば、米国特許第５３９１５２２号明細書には、重量％表示で、SiO_2：６５～８３％、Li_2O：８～１３％、K_2O：０～７％、ＭｇＯ：０．５～５％、ＺｎＯ：０～５％、ＰｂＯ：０～５％、ただし、ＭｇＯ＋ＺｎＯ＋ＰｂＯ：０．５～５％、P_2O_5：１～４％、Al_2O_3：０～７％、$As_2O_3+Sb_2O_3$：０～２％を含み、主結晶として微細な$Li_2O\cdot2SiO_2$結晶粒子を含む磁気ディスク用結晶化ガラス基板が開示されている。

【０００３】しかしながら、近年ハードディスクに代表される磁気ディスクなどの情報記録装置には記録の高密度化、データの書きこみや読み取りの高速化が求められているため、ディスク回転の高速化が必要とされている。現在のディスクの回転速度は７２００ｒｐｍ程度ではあるが、将来的には１５０００ｒｐｍあるいはそれ以上に高速化することが予想される。特に大量のデータを処理するサーバー用ハードディスクドライブにはこの要求がさらに強くなると思われる。しかしながら、記録媒体の回転数を高めると、記録媒体にたわみが生じ共振が

大きくなり、記録媒体の表面が磁気ヘッドと衝突して読み取りエラーや磁気ヘッドがクラッシュする危険性が高くなる。したがって、現状の記録媒体では磁気ヘッドと記録媒体の距離（浮上距離）をある程度以下に小さくすることができないので、磁気記録装置の記録密度増加の阻害要因となりつつある。この記録媒体のたわみと共振の問題は高弾性率基板材料の使用により解決される。

【０００４】しかしながら、これまで一般に使用されてきたアルミニウム基板は、弾性率が７２ＧＰａ程度で、ガラス基板は８０～１００ＧＰａ程度であって高速回転化にはまだ対応できないため、基板を厚くしてハードディスクの高速回転化に対応しようとする動きがでてきている。基板の厚み増は重量増を伴うので高速回転化の消耗電力が大きくなる。したがって、密度の大きいアルミニウム合金（２．７６ｇ／ｃｍ^3）より軽い基板材料が市場から求められる。また、アルミニウム基板はガラスより表面硬度が遥かに低く塑性変形が起き易いため、高速回転基板と磁気ヘッドの衝突で記録媒体の表面が凹んでしまうおそれがある。一方、ガラス基板は、弾性率と表面硬度及び表面平滑性ともにアルミニウム基板よりも優れているが、アルミニウム基板より脆いため傷つきやすく、製造工程において形成されるわずかな傷の存在が破損につながる。例えば、磁気ディスク基板としてガラスを用いる場合、円形加工、芯抜き、内外円周面加工など多くの加工処理が必要となる。これらの加工処理中にやはりガラスエッジ部などに破壊基点となりうる傷が多数発生し、製造工程においてのみならずスピンドルへの装着その他取り扱い時においても形成されるわずかな傷が基板破損につながる。特に磁気ディスク回転の高速化にともなってこの問題がより重要となる。これらの問題を解決するため、密度が小さくかつ傷つきにくい基板ガラス、またはガラスの破壊進行に対する抵抗力すなわち破壊靭性が高い基板ガラスを提供することが必要となる。

【０００５】

【発明が解決しようとする課題】本発明は、このような事情のもとで、高速回転化や高記録密度化動向に対応することのできる、密度が小さく、かつ耐擦傷性に優れ、傷が付きにくい上、破壊進行に対する抵抗力、すなわち破壊靭性の大きな情報記録媒体用ガラス基板、およびそれを用いた磁気情報記録媒体を提供することを目的とするものである。

【０００６】

【課題を解決するための手段】本発明者らは、前記目的を達成するために鋭意研究を重ねた結果、水中および／または乾燥雰囲気において測定された脆さ指標値がある値以下のガラス基板、あるいは特定の組成のガラスからなるガラス基板が、情報記録媒体用ガラス基板として、その目的に適合し得ることを見出し、この知見に基づいて本発明を完成するに至った。

【０００７】すなわち、本発明は、（１）水中における脆さ指標値が１２$\mu m^{-1/2}$以下であることを特徴とする情報記録媒体用ガラス基板（以下、情報記録媒体用ガラス基板Ｉと称す。）、（２）露点が－５℃以下の雰囲気における脆さ指標値が７$\mu m^{-1/2}$以下であることを特徴とする情報記録媒体用ガラス基板（以下、情報記録媒体用ガラス基板IIと称す。）、（３）水中における脆さ指標値が１２$\mu m^{-1/2}$以下であり、かつ露点が－５℃以下の雰囲気における脆さ指標値が７$\mu m^{-1/2}$以下であることを特徴とする情報記録媒体用ガラス基板（以下、情報記録媒体用ガラス基板IIIと称す。）、（４）モル％で、SiO_2と、B_2O_3および／またはAl_2O_3とを合計量で６５％より多く含むと共に、ＲＯ（ＲはＭｇ、Ｃａ、Ｚｎ、ＳｒおよびＢａの中から選ばれる少なくとも１種）０～２０％、R'_2O（Ｒ'はＬｉ、ＮａおよびＫの中から選ばれる少なくとも１種）０～２８％、TiO_2 ０～１０％およびZrO_2 ０～１０％を含み、かつ上記成分の合計含有量が９５％以上であるガラスからなる上記（１）、（２）または（３）に記載の情報記録媒体用ガラス基板、

【０００８】（５）モル％で、SiO_2 ４０～７５％、B_2O_3および／またはAl_2O_3 ２～４５％およびR'_2O（Ｒ'はＬｉ、ＮａおよびＫの中から選ばれる少なくとも１種）０～４０％を含み、かつSiO_2とB_2O_3とAl_2O_3とR'_2Oとの合計含有量が９０％以上であるガラスからなることを特徴とする情報記録媒体用ガラス基板（以下、情報記録媒体用ガラス基板IVと称す。）、（６）水中における脆さ指標値が１２$\mu m^{-1/2}$以下である上記（５）に記載の情報記録媒体用ガラス基板、（７）露点が－５℃以下の雰囲気における脆さ指標値が７$\mu m^{-1/2}$以下である上記（５）または（６）に記載の情報記録媒体用ガラス基板、（８）ヤング率が７０ＧＰａ以上である上記（１）ないし（７）のいずれか１項に記載の情報記録媒体用ガラス基板、（９）剛性率が２０ＧＰａ以上である上記（１）ないし（８）のいずれか１項に記載の情報記録媒体用ガラス基板、（１０）液相温度以上の温度領域において、粘度が１Ｐａ・ｓ以上である領域を有するガラスからなる上記（１）ないし（９）のいずれか１項に記載の情報記録媒体用ガラス基板、

【０００９】（１１）熱膨張係数が、１００～３００℃の温度において、６０×10^{-7}／℃以上であるガラスからなる上記（１）ないし（１０）のいずれか１項に記載の情報記録媒体用ガラス基板、（１２）化学強化層を有さない上記（１）ないし（１１）のいずれか１項に記載の情報記録媒体用ガラス基板、（１３）化学強化層を有する上記（１）ないし（１１）のいずれか１項に記載の情報記録媒体用ガラス基板、および（１４）上記（１）ないし（１３）のいずれか１項に記載の情報記録媒体用ガラス基板上に、少なくとも磁気記録層を有することを

特徴とする磁気情報記録媒体、を提供するものである。

【００１０】

【発明の実施の形態】本発明の情報記録媒体用ガラス基板には、四つの態様、すなわち情報記録媒体用ガラス基板Ｉ～IVがある。本発明の情報記録媒体用ガラス基板Ｉは、水中における脆さ指標値が１２$\mu m^{-1/2}$以下のガラス基板である。この水中における脆さ指標値は、その値が低いほど、脆くないガラス基板となる。該水中における脆さ指標値は、好ましくは１０．５$\mu m^{-1/2}$以下、より好ましくは９$\mu m^{-1/2}$以下、さらに好ましくは８$\mu m^{-1/2}$以下である。水中における脆さ指標値がこのような値であることにより、研磨液に浸った状態で行われるガラス基板の研磨加工時や、研磨液、洗浄液でぬれている状態のガラス基板のハンドリング時の破壊が起こりにくくなる。

【００１１】本発明の情報記録媒体用ガラス基板IIは、露点が－５℃以下の雰囲気における脆さ指標値が７$\mu m^{-1/2}$以下のガラス基板である。該指標値は、好ましくは６$\mu m^{-1/2}$以下、より好ましくは５$\mu m^{-1/2}$以下、さらに好ましくは４$\mu m^{-1/2}$以下である。露点が－５℃以下の雰囲気、すなわち乾燥雰囲気における脆さ指標値がこのような値であることにより、乾燥雰囲気において、情報記録媒体用ガラス基板をハンドリングする際や、該ガラス基板を用いた情報記録媒体の使用時に破壊が起こりにくい。

【００１２】本発明の情報記録媒体用ガラス基板III は、水中における脆さ指標値が１２$\mu m^{-1/2}$以下であり、かつ露点が－５℃以下の雰囲気における脆さ指標値が７$\mu m^{-1/2}$以下のガラス基板である。上記水中における脆さ指標値は、好ましくは１０．５$\mu m^{-1/2}$以下、より好ましくは９$\mu m^{-1/2}$以下、さらに好ましくは８$\mu m^{-1/2}$以下であり、上記露点－５℃以下の雰囲気における脆さ指標値は、好ましくは６$\mu m^{-1/2}$以下、より好ましくは５$\mu m^{-1/2}$以下、さらに好ましくは４$\mu m^{-1/2}$以下である。このガラス基板IIIは、前記ガラス基板ＩおよびIIの両方の性質を備えており、いかなる環境下に使用したり、ハンドリングしても、破壊が起こりにくい。

【００１３】本発明においては、前記ガラス基板の脆さ指標値として、B.R.Ｌａｗｎらによって提案された脆さ指標値Ｂを採用する［「ジャーナル・オブ・ジ・アメリカン・ケミカル・ソサエティ（J.Am.Ｃｈｅｍ.Ｓｏｃ.）」第６２巻、第３４７～３５０ページ（１９７９年）］。ここで、脆さ指標値Ｂは、ガラスのビッカース硬度値Ｈｖと破壊靭性値Ｋｃから、式Ｂ＝Ｈｖ／Ｋｃから定義される。

【００１４】ガラスのビッカース硬度値Ｈｖと破壊靭性値Ｋｃは、ビッカース硬度計の鋭いダイヤモンド圧子をガラスに押し込む方法により測定することができる。すなわち、ガラスの硬度はビッカース圧子を押しこんだときにガラスの表面に残る圧子の圧痕の大きさより次式で求められる。

【００１５】

【数１】

$$Hv = 1.8544 \times \frac{P}{(2a)^2}$$

【００１６】ここで、Ｐはビッカース圧子の押しこみ荷重であり、ａはビッカース圧痕の対角線長である。一方、ガラスの破壊靭性Ｋｃはビッカース圧子を押しこんだときにガラスの表面に残る圧子の圧痕の大きさと圧痕の隅から発生するクラックの長さより次式で求められる。

【００１７】

【数２】

$$Kc = 0.026 \frac{E^{\frac{1}{2}} P^{\frac{1}{2}} a}{C^{\frac{3}{2}}}$$

【００１８】ここで、Ｅはガラスのヤング率、Ｃは圧痕の隅から発生するクラックの長さである。Ｋｃを正しく求めるための必要条件はＣ／ａ比が２．５以上に大きくなることである。

【００１９】ガラスの脆さ指標値Ｂは、上記で求めたＨｖおよびＫｃから、Ｂ＝Ｈｖ／Ｋｃで算出されるが、本発明においては、後述の比較例と比較するために、該比較例を記載する特開平１０－１５８０２８号公報に示した方法、すなわち

【００２０】

【数３】

$$B = 2.39 \times \left[\frac{C}{a}\right]^{\frac{3}{2}} P^{\frac{1}{4}}$$

【００２１】により算出した値を採用する。

【００２２】特開平１０－１５８０２８号公報に示した計算式を用いた脆さの値とＨｖ／Ｋｃ式で評価した脆さの値との差は殆ど５％以下であるので、特開平１０－１５８０２８号公報に示した式を用いても正しく評価できる。実際には特開平１０－１５８０２８号公報に示した計算式はＬａｗｎらのＨｖ／Ｋｃ計算式をベースにして導出されたもので、基本概念が同じである。

【００２３】水中における脆さ指標値は、試料表面に純水の水滴を落とし、３０秒後にその水滴の上からビッカース圧子を押し込み圧痕およびクラックを導入する。その後すぐに試料を純水中に浸漬し２４時間後に取り出し水を拭き取り、直ちに、圧痕、クラックの大きさを測定して算出した値である。また、露点が－５℃以下の雰囲気における脆さ指標値は、乾燥窒素雰囲気下で、試料周辺の露点を測定し、該露点が－５℃以下であることを確認しながら、ビッカース圧子を押し込み圧痕およびクラ

ックを導入し、それらの大きさを測定して算出した値である。

【００２４】本発明の情報記録媒体用ガラス基板Ｉ、II及びIIIは、前述のような脆さ指標値を有することから、傷が付きにくい上、従来のガラスと同等な化学強化も可能であるため、製造工程における破損や、製品として使用中の破損を大幅に減少させることができる。

【００２５】このようなガラス基板Ｉ～IIIとしては、ガラス組成として、モル％で、SiO_2と、B_2O_3および／またはAl_2O_3とを合計量で６５％より多く含むと共に、ＲＯ（ＲはＭｇ、Ｃａ、Ｚｎ、ＳｒおよびＢａの中から選ばれる少なくとも１種）０～２０％、R'_2O（R'はＬｉ、ＮａおよびＫの中から選ばれる少なくとも１種）０～２８％、TiO_2 ０～１０％およびZrO_2 ０～１０％を含み、かつ上記成分の合計含有量が９５％以上であるガラスからなるものを挙げることができる。

【００２６】このガラス組成において、SiO_2と、B_2O_3および／またはAl_2O_3との合計含有量は、好ましくは６５モル％より多く９０モル％以下、より好ましくは７０～９０モル％、さらに好ましくは７０～８５モル％の範囲である。また、SiO_2の含有量は、好ましくは４０～７５モル％、より好ましくは５０～７０モル％であり、Al_2O_3の含有量は、好ましくは０～２５モル％、より好ましくは１～２０モル％、さらに好ましくは２～１５モル％である。B_2O_3の含有量は、好ましくは０～２５モル％、より好ましくは１～２５モル％、さらに好ましくは２～２０モル％である。前記ＲＯの含有量は、好ましくは１５モル％以下、より好ましくは１２モル％以下である。また、ＭｇＯの含有量は、好ましくは１５モル％以下、より好ましくは１２モル％以下であり、ＣａＯの含有量は、好ましくは１０モル％以下、より好ましくは８モル％以下である。ＺｎＯの含有量は、好ましくは１０モル％以下、より好ましくは８モル％以下であり、ＳｒＯの含有量は、好ましくは１０モル％以下、より好ましくは８モル％以下である。ＢａＯの含有量は、好ましくは１０モル％以下、より好ましくは５モル％以下である。このＲＯとしては、ＭｇＯが好ましい。

【００２７】R'_2Oの含有量は、好ましくは２５モル％以下、より好ましくは１０～２５モル％である。また、Li_2Oの含有量は、好ましくは２０モル％以下、より好ましくは１８モル％以下、さらに好ましくは５～１５モル％であり、Na_2Oの含有量は、好ましくは２０モル％以下、より好ましくは１５モル％以下、さらに好ましくは１～１０モル％である。K_2Oの含有量は、好ましくは１５モル％以下、より好ましくは１０モル％以下、さらに好ましくは０～８モル％である。また、SiO_2とB_2O_3とAl_2O_3とＲＯとR'_2Oとの合計含有量は、好ましくは８５モル％以上、より好ましくは９０モル％以上、さらに好ましくは９５モル％以上である。

【００２８】さらに、TiO_2の含有量は、好ましくは０～７モル％、より好ましくは０～５モル％であり、ZrO_2の含有量は、好ましくは０～８モル％、より好ましくは０～６モル％である。また、SiO_2とB_2O_3とAl_2O_3とＲＯとR'_2OとTiO_2とZrO_2との合計含有量は、好ましくは９５モル％以上、より好ましくは９８モル％以上である。さらに、B_2O_3とAl_2O_3のモル比（B_2O_3／Al_2O_3）は０．５～１．５の範囲が好ましく、より好ましくは０．８～１．２の範囲である。

【００２９】以上の成分の組み合わせとしては、例えばモル％で、SiO_2 ４０～７５％、B_2O_3 １～２５％、Al_2O_3 １～２０％（ただし、SiO_2とB_2O_3とAl_2O_3との合計含有量が６５％を超える。）、ＭｇＯ ０～１５％、ＺｎＯ ０～１０％、ＣａＯ ０～１０％、ＳｒＯ ０～１０％、ＢａＯ ０～１０％（ただし、ＭｇＯとＣａＯとＺｎＯとＳｒＯとＢａＯの合計含有量が２０％未満である。）、Li_2O ０～２０％、Na_2O ０～２０％、K_2O ０～１５％（ただし、Li_2OとNa_2OとK_2Oとの合計含有量が２８％未満である。）、TiO_2 ０～１０％およびZrO_2 ０～１０％を含み、かつ上記成分の合計含有量が９５％以上であるガラス挙げることができる。

【００３０】SiO_2はガラスの網目構造を形成する主成分であり、その含有量は、４０モル％未満では、ガラスの耐久性が悪化し、ガラスが失透しやすくなる。一方、７５モル％を超えると、高温粘性が高くなり、ガラスが溶けにくくなる。したがって、SiO_2の含有率は４０～７５モル％の範囲が好ましく、特に５０～７０モル％の範囲が好ましい。

【００３１】B_2O_3は本発明の重要な成分である。SiO_2の代わりにB_2O_3を導入すると、ガラスの脆さが大幅に低下し、比重も低くなる上、高温粘性も低下してガラスの溶解性が大きく改善される。しかし、その導入量が２５モル％を超えて多くなると、ガラスの耐久性が悪化し、分相しやすくなるので良質なガラスが作れなくなる場合がある。一方、その導入量が１モル％未満では脆さが悪化し、高温粘性も高くなるので、低コストの量産化ができなくなるおそれがある。したがって、B_2O_3の含有量は１～２５モル％が好ましく、特に２～２０モル％の範囲が好ましい。

【００３２】Al_2O_3はガラスに耐熱性や耐久性及び低脆性を寄与する成分としても、SiO_2とともにガラス構造の安定化及びその剛性度を高める成分としても非常に重要である。しかし、その含有率が１モル％未満ではガラスからのアルカリの溶出を抑える効果が小さく、耐久性のよいガラスを作りにくいし、２０モル％を超えて導入すると、ガラスの高温溶融性が悪化するので、その含有率は１～２０モル％の範囲が好ましく、より好ましくは２～１５モル％の範囲である。

【００３３】ＭｇＯ、ＣａＯ、ＺｎＯ、ＳｒＯ及びＢａＯはガラスの溶解時の粘性を下げ、溶融性や量産性を高めるために導入された成分である。合計含有量が２０モル％以上では脆さが高くなるのでガラスが傷つきやすくなり、比重も失透温度も高くなる傾向がある。ガラスの溶解性と低脆性の両方を考慮してＭｇＯ、ＣａＯ、ＺｎＯ、ＳｒＯ及びＢａＯの含有量は、ＭｇＯが０～１５モル％、好ましくは０～１２モル％、ＺｎＯが０～１０モル％、好ましくは０～８モル％、ＣａＯが０～１０モル％、好ましくは０～８モル％、ＳｒＯが０～１０モル％、好ましくは０～８モル％、ＢａＯが０～１０モル％、好ましくは０～５モル％の範囲であり、それらの合計含有量は好ましくは２０モル％未満、より好ましくは１５モル％以下である。

【００３４】Li_2O、Na_2O、K_2Oはガラスの溶解時の粘性を下げ、溶解を促進するとともに、ガラスの脆さを低くする非常に有用な成分である。しかし、その導入量が２８％以上になると、化学的耐久性が悪化するだけでなく、アルカリがガラス表面に多く析出するようになるため、磁性膜を侵食してしまう恐れがあるので、Li_2O、Na_2O、K_2Oの含有量を、Li_2Oが０～２０モル％、好ましくは０～１８モル％、Na_2Oが０～２０モル％、好ましくは０～１５モル％、K_2Oが０～１５モル％、好ましくは０～１０モル％とすると共に、それらの合計含有量を好ましくは２８モル％未満、より好ましくは２５モル％以下に抑える。

【００３５】SiO_2とB_2O_3とAl_2O_3との合計含有量は、好ましくは７０～９０モル％、より好ましくは８０～９０モル％の範囲であり、ＲＯとＲ'$_2$Ｏとの合計含有量は、好ましくは５～３５モル％、より好ましくは１０～３０モル％、さらに好ましくは１０～２５モル％、特に好ましくは１０～２２モル％である。

【００３６】ZrO_2、TiO_2はガラスの化学的耐久性を向上させ、剛性度を高めるために導入される成分である。少量のZrO_2及びTiO_2をガラスに添加すると、ガラスの耐久性も弾性率も脆さも改善されるが、比重が急増するし、より多く導入するとガラスの失透傾向が強くなる。したがって、ZrO_2とTiO_2の含有量がそれぞれ０～１０モル％、好ましくは０～７モル％および０～１０モル％、好ましくは０～８モル％に制限される。また、上記成分の合計含有量は９５モル％以上である。

【００３７】このガラスには、上記成分以外に、ガラスの溶解性、清澄性、成形性などを改善するため、As_2O_3、Sb_2O_3、Ｆ、Ｃｌ、SO_3を合計で２モル％以下に導入することが可能である。また、ガラスの耐久性や弾性率を向上させるため、Y_2O_3、La_2O_3などの希土類金属酸化物などその他の酸化物を５モル％以下の割合で添加できる。

【００３８】さらに、モル％で、SiO_2　５５～７５％、B_2O_3　０～２０％、Al_2O_3　１～２０％（ただし、SiO_2とB_2O_3とAl_2O_3との合計含有量が６５％以上）、ＭｇＯ　０～１５％、ＺｎＯ　０～１０％、ＣａＯ　０～１０％、ＳｒＯ　０～１０％、ＢａＯ　０～１０％（ただし、ＭｇＯとＣａＯとＺｎＯとＳｒＯとＢａＯの合計含有量（ＲＯの含有量）が２０％以下）、Li_2O　０～２０％、Na_2O　０～２０％、K_2O　０～６％（ただし、Li_2OとNa_2OとK_2Oとの合計含有量（Ｒ'$_2$Ｏ含有量）が２８％以下）、TiO_2　０～１０％およびZrO_2　０～１０％を含み、かつ上記成分の合計含有量が９５％以上のガラスも挙げることができる。

【００３９】本発明の情報記録媒体用ガラス基板IVは、モル％でSiO_2　４０～７５％、B_2O_3および／またはAl_2O_3　２～４５％およびＲ'$_2$Ｏ（Ｒ'はＬｉ、ＮａおよびＫの中から選ばれる少なくとも１種）０～４０％を含み、かつSiO_2とB_2O_3とAl_2O_3とＲ'$_2$Ｏとの合計含有量が９０％以上であるガラスからなるものである。

【００４０】このガラス組成において、SiO_2の含有量は５０～７０モル％が好ましく、B_2O_3の含有量は、好ましくは０～２５モル％、より好ましくは１～２５モル％、さらに好ましくは２～２０モル％であり、Al_2O_3の含有量は、好ましくは０～２５モル％、より好ましくは１～２０モル％、さらに好ましくは２～１５モル％である。SiO_2とB_2O_3とAl_2O_3との合計含有量は、好ましくは６５～９０モル％、より好ましくは７０～９０モル％、さらに好ましくは７０～８５モル％である。Ｒ'$_2$Ｏ含有量は、好ましくは０～２８モル％（ただし、ＲＯが０モル％の場合は０を除く）、より好ましくは２５モル％以下、さらに好ましくは１０～２５モル％である。Li_2Oの含有量は、好ましくは２０モル％以下、より好ましくは１８モル％以下、さらに好ましくは５～１５モル％であり、Na_2Oの含有量は、好ましくは２０モル％以下、より好ましくは１５モル％以下、さらに好ましくは１～１０モル％であり、K_2Oの含有量は、好ましくは１５モル％以下、より好ましくは１０モル％以下、さらに好ましくは０～８モル％である。さらに、ＲＯの含有量は、好ましくは１５モル％以下、より好ましくは１２モル％以下である。また、ＭｇＯの含有量は、好ましくは１５モル％以下、より好ましくは１２モル％以下であり、ＣａＯの含有量は、好ましくは１０モル％以下、より好ましくは８モル％以下である。ＺｎＯの含有量は、好ましくは１０モル％以下、より好ましくは８モル％以下であり、ＳｒＯの含有量は、好ましくは１０モル％以下、より好ましくは８モル％以下である。ＢａＯの含有量は、好ましくは１０モル％以下、より好ましくは５モル％以下である。ＲＯとしては、特にＭｇＯが好ましい。

【００４１】ＲＯとＲ'$_2$Ｏとの合計含有量は、好ましくは５～３５モル％、より好ましくは１０～３０モル％、

さらに好ましくは１０～２５モル％、特に好ましくは１０～２２モル％である。さらに、TiO_2　０～１０モル％を含むことができ、好ましいTiO_2の含有量は０～７モル％である。またZrO_2　０～１０モル％を含むことができ、好ましいZrO_2含有量は０～７モル％である。

【００４２】このガラス基板IVは、水中における脆さ指標値を１２$\mu m^{-1/2}$以下、好ましくは１０．５$\mu m^{-1/2}$以下、より好ましくは９$\mu m^{-1/2}$以下、さらに好ましくは８$\mu m^{-1/2}$以下とすることができる。また、露点が－５℃以下の雰囲気における脆さ指標値を７$\mu m^{-1/2}$以下、好ましくは６$\mu m^{-1/2}$以下、より好ましくは５$\mu m^{-1/2}$以下、さらに好ましくは４$\mu m^{-1/2}$以下とすることができる。

【００４３】本発明の情報記録媒体用ガラス基板Ｉ～IVにおいては、ヤング率を７０ＧＰａ以上、好ましくは７５ＧＰａ以上、より好ましくは８５ＧＰａ以上とすることができる。

【００４４】薄肉のガラス基板を含む情報記録媒体を高速回転させた際に当該ガラス基板が共振等によって変形するのを防止する上からは、ガラス基板のヤング率を高めることが好ましい。例えばヤング率が７０ＧＰａ以上のガラスからなる、直径３．５インチ、厚さ０．６３５mmのガラス基板を用いて作製した磁気ディスクを１００００ｒｐｍで回転させた際に、当該磁気ディスクと記録再生ヘッドとのフライングハイトを概ね１μm以下で安定に確保することができる。

【００４５】また、水中における脆さ指標値の低いガラス基板において、さらにヤング率が７０ＧＰａ以上であることにより、ガラス基板を研磨液に浸った状態で研削、研磨する際の割れや、研磨液や洗浄液でぬれた状態のガラス基板をハンドリングする際の破壊が格段に起こりにくくなる。

【００４６】さらに、水中および／または乾燥雰囲気中における脆さ指標値の低いガラス基板において、さらにヤング率が７０ＧＰａ以上であることにより、ガラス基板が回転や荷重によりたわみにくいため、ガラス基板の研磨加工時や情報記録媒体使用時、特に情報記録媒体が高速回転する際の破壊がさらに起こりにくくなる。

【００４７】また、本発明のガラス基板Ｉ～IVにおいては、剛性率を２０ＧＰａ以上、好ましくは２５ＧＰａ以上、より好ましくは３０ＧＰａ以上とすることができる。

【００４８】薄肉のガラス基板を含む情報記録媒体を高速回転させた際に当該ガラス基板が共振等によって変形するのを防止する上からは、ガラス基板の剛性率を高めることが好ましい。例えば剛性率が２０ＧＰａ以上のガラスからなる、直径３．５インチ、厚さ０．６３５mmのガラス基板を用いて作製した磁気ディスクを１００００ｒｐｍで回転させた際に、当該磁気ディスクと記録再生ヘッドとのフライングハイトを概ね１μm以下で安定に確保することができる。

【００４９】また、水中における脆さ指標値の低いガラス基板において、さらに剛性率が２０ＧＰａ以上であることにより、ガラス基板を研磨液に浸った状態で研削、研磨する際の割れや、研磨液や洗浄液でぬれた状態のガラス基板をハンドリングする際の破壊が格段に起こりにくくなる。

【００５０】さらに、水中および／または乾燥雰囲気中における脆さ指標値の低いガラス基板において、さらに剛性率が２０ＧＰａ以上であることにより、ガラス基板が回転や荷重によりたわみにくいため、ガラス基板の研磨加工時や情報記録媒体使用時、特に情報記録媒体が高速回転する際の破壊がさらに起こりにくくなる。

【００５１】また、本発明のガラス基板Ｉ～IVにおいて、比弾性率（ヤング率をその密度で除した値）が２７×10^6Ｎ・ｍ／ｋｇ以上とすることができる。この比弾性率が２７×10^6Ｎ・ｍ／ｋｇ以上では、情報記録媒体の高速回転時のたわみを２μm以下にすることができ、その結果として、フライングハイトを１μm以下で安定に確保することできる。また、高速回転時のたわみが少ないことにより、脆さ指標値の小さいガラス基板では、破壊がさらに起こりにくくなる。この比弾性率は３０×10^6Ｎ・ｍ／ｋｇ以上であることがより好ましい。

【００５２】また、本発明のガラス基板Ｉ～IVにおいては、密度を２．６５ｇ／cm^3以下、好ましくは２．５０ｇ／cm^3以下とすることもできる。さらに、本発明のガラス基板Ｉ～IVにおいては、破壊靭性値を０．７５ＭＰａ／$m^{1/2}$以上、好ましくは０．８０ＭＰａ／$m^{1/2}$以上、より好ましくは０．８３ＭＰａ／$m^{1/2}$以上である。破壊靭性値が０．７５ＭＰａ／$m^{1/2}$以上であるとガラス基板加工時や、情報記録媒体の使用時における破壊が起こりにくくなる。

【００５３】本発明の情報記録媒体用ガラス基板Ｉ～IVにおいては、液相温度以上の温度領域において、粘度が１Ｐａ・ｓ以上である領域を有するガラスからなるものが好ましい。

【００５４】情報記録媒体用ガラス基板を得るためには、その製造工程で実質的に失透しないようにする必要があり、そのためには少なくとも原料の溶解、溶解したガラスの成形型への供給を液相温度以上で行う必要がある。このため、本発明のガラス基板Ｉ～IVにおいては材料ガラスの液相温度を１３５０℃以下とすることが好ましく、１２５０℃以下であることがより好ましく、１１５０℃以下であることが特に好ましい。

【００５５】ここで、溶融ガラスを成形型へ供給する際の粘度が１Ｐａ・ｓ未満であると、溶融ガラスの流量の制御が困難になるばかりか、プレス成形により薄肉で平坦な情報記録媒体用ガラス基板を得ることが困難とな

る。なお、本発明のガラス基板Ｉ～IVは、液相温度以上の温度領域において粘度が３Ｐａ・ｓ以上である領域を有するガラスからなるものが、より好ましい。

【００５６】本発明のガラス基板Ｉ～IVにおいては、材料ガラスの転移点を４７０～６４０℃とすることができる。ガラス転移点が高すぎるとプレス成形できる温度領域が狭くなり、薄肉のガラス基板をプレス成形しにくくなるし、一方、ガラス転移点が低すぎるとガラス基板に記録層などの磁性膜を形成する際または形成した後に、磁気特性の向上などの目的で行う加熱処理温度の範囲が狭くなる。好ましい転移点は４７０～６２０℃の範囲である。

【００５７】本発明の情報記録媒体用ガラス基板Ｉ～IVにおいては、熱膨張係数が、１００～３００℃の温度において、６０×10^{-7}／℃以上であるガラスからなるものが好ましい。磁気ディスク、光ディスク、光磁気ディスク等の情報記録媒体へ情報を記録する際、あるいは、当該情報記録媒体に記録されている情報を再生する際には、当該情報記録媒体は情報処理装置内に設けられているドライブモータのスピンドルにクランプによって固定された状態で回転するが、この際、情報記録媒体の熱膨張係数と前記のクランプの熱膨張係数とが著しく異なっていると、次のような問題が生じる。

【００５８】すなわち、情報記録媒体を回転させる際には、ドライブモータの発熱等によって、情報記録媒体、スピンドル、クランプ等の温度が例えば９０℃程度まで急激に昇温するが、情報記録媒体の熱膨張係数と前記のクランプの熱膨張係数とが著しく異なっていると、前記の昇温によって情報記録媒体とクランプとの間で緩みが生じたり、情報記録媒体に歪みや撓みが生じ、その結果として、情報記録媒体におけるデータ記録箇所（トラック）の位置が変化して、情報の記録あるいは再生にエラーが生じやすくなる。このような問題は、特に、３．５インチのような大きな基板で問題になる。

【００５９】したがって、本発明のガラス基板Ｉ～IVの熱膨張係数は前記のクランプの熱膨張係数にできるだけ近似していることが好ましい。前記のクランプは一般にステンレス合金によって作製されているので、本発明のガラス基板Ｉ～IVの１００～３００℃における熱膨張係数は、６０×10^{-7}／℃以上であるのが好ましく、より好ましくは７０×10^{-7}／℃以上、さらに好ましくは７０×10^{-7}／℃～１２０×10^{-7}／℃、特に好ましくは８０×10^{-7}／℃～１００×10^{-7}／℃である。

【００６０】本発明の情報記録媒体用ガラス基板Ｉ～IVは、化学強化層を有していないものであってもよいし、所望により、公知の化学強化処理を行い、化学強化層を設けたものであってもよい。化学強化処理を行う場合には、前述のガラス組成の範囲の中から、化学強化処理に適した組成を選択するのがよい。

【００６.１】化学強化処理は、イオン交換法によって行うことができる。このイオン交換法は、Ｎａイオン、Ｋイオンを含有する溶融塩を用いて行われ、化学強化ガラスが得られる。Ｎａイオン、Ｋイオンを含む処理溶融塩としては、硝酸ナトリウム、硝酸カリウム及びその混合溶融塩を用いるのが好ましいが、硝酸塩に限定されるものではなく、硫酸塩、重硫酸塩、炭酸塩、ハロゲン化物などを用いてもよい。前述のように、本発明で用いるガラスは、低脆さ高破壊靭性を有し、イオン交換により曲げ強度も高くなるので、得られた化学強化ガラスは優れた破壊耐性を有する。

【００６２】本発明の情報記録媒体用ガラス基板の製造方法としては特に制限はなく、各種の方法を用いることができる。例えば、高温溶融法すなわち所定の割合のガラス原料を空気中か不活性ガス雰囲気で溶解し、バブリングや攪拌などによってガラスの均質化を行い、周知のプレス法、ダウンドロー法及びフロート法により板ガラスに成形され、その後、円形加工、芯抜き、内外円周加工、研削、研磨などが施され、所望のサイズ、形状の情報記録媒体用基板とされる。なお、研磨では研磨材やダイヤモンドペレットによりラッピング及び酸化セリウムなどの研磨材によるポリシング加工を行うことで、表面精度を例えば０．１～０．６ｎｍの範囲にすることができる。

【００６３】本発明の磁気情報記録媒体は、前述の本発明の情報記録媒体用ガラス基板Ｉ～IV上に、少なくとも磁気記録層を有するものであり、該磁気情報記録媒体の構成としては、例えば前記ガラス基板上に、順次下地層、磁気記録層、保護層、潤滑層を順次設けた構成を挙げることができる。

【００６４】ここで、磁気記録層としては、例えばＣｏ－Ｃｒ系、Ｃｏ－Ｃｒ－Ｐｔ系、Ｃｏ－Ｎｉ－Ｃｒ系、Ｃｏ－Ｎｉ－Ｐｔ系、Ｃｏ－Ｎｉ－Ｃｒ－Ｐｔ系及びＣｏ－Ｃｒ－Ｔａ系などを用いることができる。下地層としては、例えばＮｉ層、Ｎｉ－Ｐ層、Ｃｒ層などを用いることができ、保護層としては、例えばカーボン膜などを用いることができ、潤滑層としては、例えばパーフルオロポリエーテル系などの潤滑材を使用することができる。

【００６５】

【実施例】次に、本発明を実施例により、さらに詳細に説明するが、本発明は、これらの例によってなんら限定されるものではない。

【００６６】なお、各例で得られたガラスの物性は、以下に示す方法に従って測定した。

（１）ヤング率

２０×２０×１００ｍｍの試料を作製し、５ＭＨｚの超音波が前記の試料中を伝播する際の縦波速度（Vl）と横波速度（Vs）とをシングアラウンド式音速測定装置（超音波工業社製のＵＶＭ－２）を用いて測定した後、次式によって求めた。

ヤング率＝（$4G^2-3G\cdot Vl^2\cdot\rho$）／（$G-Vl^2\cdot\rho$）

$G=Vs^2\cdot\rho$

ρ：試料の密度（g／cm^3）

【００６７】（２）剛性率

上記（１）のヤング率測定時にＧとして剛性率を求めることができる。

（３）液相温度

試料を白金製の容器に入れて傾斜温度炉内に３０分間放置した後、試料の表面および内部における結晶の有無を光学顕微鏡を用いて観察した。そして、結晶が析出しない最低温度を液相温度とした。

（４）ガラス転移点（Tg）、屈服点（Ｔｄ）

５ｍｍφ×２０ｍｍの試料について、リガク社製の熱機械分析装置（ＴＭＡ８１４０）を用いて＋４℃／分の昇温速度で測定した。なお、標準試料としてはSiO_2を用いた。

【００６８】（５）熱膨張係数

１００～３００℃における平均熱膨張係数を意味し、ガラス転移点の測定時に一緒に測定した。

（６）脆さ指標値

（株）明石製作所の微小硬度計（ＭＶＫ-Ｅ）を用いて、２ｍｍ厚の板状に加工した試料に対して表１～表１５中に示した押し込み荷重でビッカース圧子を押し込み、試料に圧痕及びクラックを導入した。

【００６９】押し込み荷重は、プロバビリティーが６０以上となるような値にすることが、正確な脆さ指標値、ビッカース硬度、破壊靭性等を測定するうえで好ましく、７０以上となるような値がより好ましく、８０以上となるような値がさらに好ましい。測定されたビッカース圧痕の対角線長ａ、ビッカース圧子を押し込んだときに試料表面に生じる、ビッカース圧痕の隅から発生するクラックの長さＣを測定した。以上の測定値より、前記数式（１）～（３）を用いて、ビッカース硬度Ｈｖ、破壊靭性Ｋｃ、脆さ指標値Ｂを求めた。

【００７０】なお、水中における脆さ指標値Ｂ、ビッカース硬度Ｈｖ、破壊靭性Ｋｃ等を求めるためには、試料表面に純粋の水滴を落とし、３０秒後にその水滴の上からビッカース圧子を試料に押し込み圧痕及びクラックを導入する。

【００７１】また、露点が－５℃以下の雰囲気における脆さ指標値Ｂ、ビッカース硬度Ｈｖ、破壊靭性Ｋｃ等を求めるためには、乾燥窒素雰囲気下で、試料周辺の露点が－５℃以下であることを確認しながら、試料にビッカース圧子を押し込み、圧痕及びクラックを導入する。なお、表１～表１４中のプロバビリティとは、圧痕の４つの各頂点から生じるクラックの各頂点当たりの発生確率のことである。

【００７２】実施例１～８１

表１～表１４に示す組成のガラスが得られるように、出発原料としてSiO_2、Al_2O_3、$Al(OH)_3$、B_2O_3、HBO_3、ＭｇＯ、$Mg(OH)_2$、$MgCO_3$、$CaCO_3$、$SrCO_3$、$BaCO_3$、ＺｎＯ、Li_2CO_3、Na_2CO_3、K_2CO_3、TiO_2、及びZrO_2などを用いて３００～１５００ｇ秤量し、十分に混合して調合バッチと成し、これを白金坩堝に入れ、１４００～１６００℃の温度で空気中約３～８時間ガラスの溶解を行った。溶融後、ガラス融液を４０×４０×２０ｍｍカーボン金型に流し、ガラスの転移点温度まで放冷してから直ちにアニール炉に入れ、１時間保持した後、炉内で室温まで放冷した。得られたガラスは顕微鏡で観察できるほどの結晶が析出しなかった。このようにして得られたガラスを加工して、各物性評価用のサンプルを作製し、物性評価を行った。その結果を表１～表１４に示す。

【００７３】

【表１】

表 1

		実施例					
		1	2	3	4	5	6
組成（モル%）	SiO2	0.0	10.0	20.0	30.0	40.0	45.0
	B2O3	60.0	50.0	40.0	30.0	20.0	10.0
	Al2O3	12.0	12.0	12.0	12.0	12.0	15.0
	MgO	8.0	8.0	8.0	8.0	8.0	10.0
	CaO	15.0	20.0	20.0	15.0	10.0	10.0
	ZnO	—	—	—	—	—	—
	RO	23.0	28.0	28.0	23.0	18.0	20.0
	Li2O	—	—	—	—	—	5.0
	Na2O	—	—	—	0.0	5.0	5.0
	K2O	5.0	0.0	0.0	5.0	5.0	0.0
	R'2O	5.0	0.0	0.0	5.0	10.0	10.0
	TiO2	—	—	—	—	—	—
	ZrO2	—	—	—	—	—	—
	SiO2+B2O3+Al2O3	72.0	72.0	72.0	72.0	72.0	70.0
	B2O3/Al2O3	5.0	4.2	3.3	2.5	1.7	0.7
	RO+R'2O	28.0	28.0	28.0	28.0	28.0	30.0
	SiO2+B2O3+Al2O3+RO+R'2O	100.0	100.0	100.0	100.0	100.0	100.0
	SiO2+B2O3+Al2O3+R'2O	77.0	72.0	72.0	77.0	82.0	80.0
	SiO2+B2O3+Al2O3+RO+R'2O+TiO2+ZrO2	100.0	100.0	100.0	100.0	100.0	100.0
	合 計	100.0	100.0	100.0	100.0	100.0	100.0
ガラス転移点 Tg[℃]		652	612	622	590	565	554
屈伏点 Td [℃]		696	660	664	643	620	609
熱膨張係数 $\alpha\times10^{-7}$[/℃]		67	56	59	66	79	67
密度 [g/cm³]		2.373	2.490	2.522	2.472	2.478	2.547
ヤング率 E[GPa]		65.28	80	81.4	75.52	72.71	87.97
剛性率 G [GPa]		25.56	—	—	30.21	29.30	35.19
水中	押し込み荷重 [gF]	1000	1000	1000	1000	1000	1000
	脆さ指標値 B [$\mu m^{-1/2}$]	11.0	9.4	10.6	7.7	8.2	9.8
	ビッカース硬度 Hv [GPa]	4.6	5.3	5.8	5.3	5.2	6.1
	破壊靭性 Kc [MPa/$m^{1/2}$]	0.46	0.61	0.56	0.73	0.66	0.64
	プロバビリティ	100	100	100	100	100	100
乾燥雰囲気 N2	押し込み荷重 [gF]	1000	1000	1000	1000	1000	1000
	脆さ保存性 B[$\mu m^{-1/2}$]	6.0	5.0	6.1	6.0	5.6	5.9
	ビッカース硬度 Hv [GPa]	—	—	—	5.5	5.1	6.1
	破壊靭性 Kc [MPa/$m^{1/2}$]	—	—	—	0.93	0.98	1.06
	プロバビリティ	—	—	—	100	40	100

【００７４】

【表２】

表 2

		実施例					
		7	8	9	10	11	12
組成（モル%）	SiO2	45.0	50.0	50.0	50.0	50.0	52.4
	B2O3	20.0	10.0	10.0	10.0	20.0	23.8
	Al2O3	10.0	10.0	10.0	12.0	12.0	9.5
	MgO	10.0	10.0	10.0	8.0	8.0	0.0
	CaO	5.0	10.0	10.0	20.0	0.0	0.0
	ZnO	—	—	—	—	—	—
	RO	15.0	20.0	20.0	28.0	8.0	0.0
	Li2O	0.0	0.0	5.0	—	0.0	0.0
	Na2O	5.0	5.0	5.0	—	5.0	4.8
	K2O	5.0	5.0	0.0	0.0	5.0	9.5
	R'2O	10.0	10.0	10.0	0.0	10.0	14.3
	TiO2	—	—	—	—	—	—
	ZrO2	—	—	—	—	—	—
	SiO2+B2O3+Al2O3	75.0	70.0	70.0	72.0	82.0	85.7
	B2O3/Al2O3	2.0	1.0	1.0	0.8	1.7	2.5
	RO+R'2O	25.0	30.0	30.0	28.0	18.0	14.3
	SiO2+B2O3+Al2O3+RO+R'2O	100.0	100.0	100.0	100.0	100.0	100.0
	SiO2+B2O3+Al2O3+R'2O	85.0	80.0	80.0	72.0	92.0	100.0
	SiO2+B2O3+Al2O3+RO+R'2O+TiO2+ZrO2	100.0	100.0	100.0	100.0	100.0	100.0
	合 計	100.0	100.0	100.0	100.0	100.0	100.0
ガラス転移点 Tg[℃]		548	595	541	676	543	478
屈伏点 Td [℃]		625	676	596	733	614	551
熱膨張係数 $\alpha \times 10^{-7}$[/℃]		77	87	71	52	70	82
密度 [g/cm³]		2.424	2.518	2.540	2.598	2.336	2.292
ヤング率 E[GPa]		68.82	76.62	88.53	86.1	81.54	53.42
剛性率G [GPa]		27.79	31.13	35.74	—	24.84	21.63
水中	押し込み荷重 [gF]	1000	1000	1000	1000	1000	1000
	脆さ指標値 B [$\mu m^{-1/2}$]	6.9	9.3	9.7	9.6	5.7	6.6
	ビッカース硬度 Hv [GPa]	5.1	5.5	5.7	5.9	4.5	4.2
	破壊靭性 Kc [MPa/$m^{1/2}$]	0.76	0.61	0.63	0.64	0.85	0.67
	プロバビリティ	95	100	100	100	95	100
乾燥雰囲気 N2	押し込み荷重 [gF]	5980	1000	1000	1000	6952	5980
	脆さ指標値 B [$\mu m^{-1/2}$]	4.5	5.9	6.1	5.4	3.4	3.4
	ビッカース硬度 Hv [GPa]	4.9	5.5	6.1	5.7	4.4	4.2
	破壊靭性 Kc [MPa/$m^{1/2}$]	1.17	0.96	1.03	1.12	1.40	1.31
	プロバビリティ	80	100	100	85	80	40

【００７５】

【表３】

表 3

		実施例					
		13	14	15	16	17	18
組成（モル%）	SiO2	55.0	55.0	55.0	55.0	60.0	60.0
	B2O3	10.0	15.0	20.0	25.0	10.0	10.0
	Al2O3	12.0	10.0	10.0	10.0	2.5	5.0
	MgO	8.0	10.0	5.0	0.0	10.0	10.0
	CaO	5.0	0.0	0.0	0.0	0.0	0.0
	ZnO	—	—	—	—	0.0	0.0
	RO	13.0	10.0	5.0	0.0	10.0	10.0
	Li2O	0.0	0.0	0.0	0.0	0.0	0.0
	Na2O	5.0	5.0	5.0	5.0	12.5	10.0
	K2O	5.0	5.0	5.0	5.0	5.0	5.0
	R'2O	10.0	10.0	10.0	10.0	17.5	15.0
	TiO2	—	—	—	—	0.0	0.0
	ZrO2	—	—	—	—	—	—
	SiO2+B2O3+Al2O3	77.0	80.0	85.0	90.0	72.5	75.0
	B2O3/Al2O3	0.8	1.5	2.0	2.5	4.0	2.0
	RO+R'2O	23.0	20.0	15.0	10.0	27.5	25.0
	SiO2+B2O3+Al2O3+RO+R'2O	100.0	100.0	100.0	100.0	100.0	100.0
	SiO2+B2O3+Al2O3+R'2O	87.0	90.0	95.0	100.0	90.0	90.0
	SiO2+B2O3+Al2O3+RO+R'2O+TiO2+ZrO2	100.0	100.0	100.0	100.0	100.0	100.0
	合計	100.0	100.0	100.0	100.0	100.0	100.0
ガラス転移点 Tg[℃]		606	568	522	472	536	541
屈伏点 Td [℃]		678	659	612	558	595	606
熱膨張係数 $\alpha \times 10^{-7}$[/℃]		70	73	66	71	99	87
密度 [g/cm³]		2.439	2.365	2.307	2.238	2.470	2.442
ヤング率 E[GPa]		72.07	65.21	58.72	49.65	73.94	72.54
剛性率G [GPa]		29.43	26.60	23.83	20.02	30.32	29.74
水中	押し込み荷重 [gF]	1000	1000	1000	1000	1000	1000
	脆さ指標値 B [$\mu m^{-1/2}$]	6.7	5.9	5.8	5.4	9.7	6.3
	ビッカース硬度 Hv [GPa]	5.0	4.8	4.4	3.9	5.1	5.1
	破壊靭性 Kc [MPa/$m^{1/2}$]	0.80	0.86	0.81	0.78	0.56	0.87
	プロバビリティ	95	100	100	100	100	100
乾燥雰囲気 N2	押し込み荷重 [gF]	5952	5980	5980	5980	5980	5980
	脆さ指標値 B [$\mu m^{-1/2}$]	4.4	3.6	3.6	3.1	4.9	4.4
	ビッカース硬度 Hv [GPa]	5.0	4.7	4.4	3.9	5.2	5.3
	破壊靭性 Kc [MPa/$m^{1/2}$]	1.24	1.41	1.33	1.36	1.12	1.23
	プロバビリティ	100	100	100	60	100	80

【００７６】

【表４】

表 4

		実施例					
		19	20	21	22	23	24
組成（モル%）	SiO2	60.0	60.0	60.0	60.0	60.0	60.0
	B2O3	10.0	10.0	10.0	10.0	10.0	10.0
	Al2O3	7.5	10.0	10.0	10.0	10.0	12.0
	MgO	10.0	5.0	10.0	5.0	7.5	8.0
	CaO	0.0	5.0	0.0	0.0	0.0	0.0
	ZnO	0.0	—	—	5.0	0.0	—
	RO	10.0	10.0	10.0	10.0	7.5	8.0
	Li2O	0.0	0.0	0.0	0.0	0.0	0.0
	Na2O	7.5	5.0	5.0	5.0	5.0	5.0
	K2O	5.0	5.0	5.0	5.0	5.0	5.0
	R'2O	12.5	10.0	10.0	10.0	10.0	10.0
	TiO2	0.0	—	—	0.0	2.5	—
	ZrO2	0.0	—	—	0.0	0.0	—
	SiO2+B2O3+Al2O3	77.5	80.0	80.0	80.0	80.0	82.0
	B2O3/Al2O3	1.3	1.0	1.0	1.0	1.0	0.8
	RO+R'2O	22.5	20.0	20.0	20.0	17.5	18.0
	SiO2+B2O3+Al2O3+RO+R'2O	100.0	100.0	100.0	100.0	97.5	100.0
	SiO2+B2O3+Al2O3+R'2O	90.0	90.0	90.0	90.0	90.0	92.0
	SiO2+B2O3+Al2O3+RO+R'2O+TiO2+ZrO2	100.0	100.0	100.0	100.0	100.0	100.0
	合　計	100.0	100.0	100.0	100.0	100.0	100.0
ガラス転移点 Tg[℃]		554	595	583	567	566	598
屈伏点 Td [℃]		619	676	686	672	672	686
熱膨張係数 $\alpha\times10^{-7}$[/℃]		85	73	77	72	77	66
密度 [g/cm³]		2.409	2.419	2.382	2.448	2.386	2.347
ヤング率 E[GPa]		69.70	70.63	67.26	66.36	66.05	62.00
剛性率G [GPa]		28.54	29.05	27.61	27.17	27.09	—
水中	押し込み荷重 [gF]	1000	1000	1000	1000	1000	1000
	脆さ指標値 B [$\mu m^{-1/2}$]	6.5	6.5	6.1	5.9	5.4	6.0
	ビッカース硬度 Hv [GPa]	5.0	5.3	5.0	4.9	4.8	5.1
	破壊靭性 Kc [MPa/$m^{1/2}$]	0.82	0.83	0.85	0.87	0.95	0.83
	プロバビリティ	100	100	100	95	100	95
乾燥雰囲気 N2	押し込み荷重 [gF]	5980	5980	5980	5980	5980	5980
	脆さ指標値 B [$\mu m^{-1/2}$]	4.2	4.5	4.0	3.9	3.8	4.9
	ビッカース硬度 Hv [GPa]	5.0	5.2	5.0	4.9	4.8	4.9
	破壊靭性 Kc [MPa/$m^{1/2}$]	1.27	1.19	1.29	1.32	1.34	1.01
	プロバビリティ	60	100	100	100	80	100

【００７７】　【表５】

表 6

		実施例					
		25	26	27	28	29	30
組成（モル%）	SiO2	60.0	60.0	65.0	65.0	65.0	65.0
	B2O3	15.0	20.0	0.0	5.0	5.0	5.0
	Al2O3	10.0	10.0	7.0	2.5	5.0	5.0
	MgO	5.0	0.0	1.0	10.0	10.0	5.0
	CaO	0.0	0.0	1.0	0.0	0.0	5.0
	ZnO	—	—	0.0	0.0	0.0	0.0
	RO	5.0	0.0	2.0	10.0	10.0	10.0
	Li2O	0.0	0.0	10.0	0.0	0.0	0.0
	Na2O	5.0	5.0	10.5	12.5	10.0	10.0
	K2O	5.0	5.0	2.5	5.0	5.0	5.0
	R'2O	10.0	10.0	23.0	17.5	15.0	15.0
	TiO2	—	—	0.0	0.0	0.0	0.0
	ZrO2	—	—	3.0	0.0	—	0.0
	SiO2+B2O3+Al2O3	85.0	90.0	72.0	72.5	75.0	75.0
	B2O3/Al2O3	1.5	2.0	0.0	2.0	1.0	1.0
	RO+R'2O	15.0	10.0	25.0	27.5	25.0	25.0
	SiO2+B2O3+Al2O3+RO+R'2O	100.0	100.0	97.0	100.0	100.0	100.0
	SiO2+B2O3+Al2O3+R'2O	95.0	100.0	95.0	90.0	90.0	90.0
	SiO2+B2O3+Al2O3+RO+R'2O+TiO2+ZrO2	100.0	100.0	100.0	100.0	100.0	100.0
	合 計	100.0	100.0	100.0	100.0	100.0	100.0
ガラス転移点 Tg[℃]		540	488	479	553	558	551
屈伏点 Td [℃]		628	583	551	612.7 628.7	634	619
熱膨張係数 $\alpha\times10^{-7}$[/℃]		69	71	98	90	85	91
密度[g/cm³]		2.326	2.259	2.535	2.461	2.440	2.483
ヤング率 E[GPa]		81.15	52.00	82.25	73.65	72.10	74.95
剛性率G [GPa]		24.81	—	33.42	30.35	29.73	30.81
水中	押し込み荷重 [gF]	1000	1000	1000	1000	1000	1000
	脆さ指標値 B [$\mu m^{-1/2}$]	8.3	6.2	9.5	7.7	7.6	9.9
	ビッカース硬度 Hv [GPa]	4.8	4.4	—	5.3	5.7	5.4
	破壊靭性 Kc [MPa/$m^{1/2}$]	0.78	0.72	—	0.72	0.73	0.56
	プロバビリティ	100	80	—	100	100	100
乾燥雰囲気 N2	押し込み荷重 [gF]	5980	5980	5980	5980	5980	5980
	脆さ指標値 B [$\mu m^{-1/2}$]	3.8	3.2	5.0	5.8	4.9	5.6
	ビッカース硬度 Hv [GPa]	4.8	4.1	6.0	5.6	5.8	5.4
	破壊靭性 Kc [MPa/$m^{1/2}$]	1.28	1.36	1.18	0.97	1.13	0.99
	プロバビリティ	100	80	100	100	100	100

【００７８】　【表６】

表 6

		実施例					
		31	32	33	34	35	36
組成（モル%）	SiO2	65.0	65.0	65.0	65.0	65.0	65.0
	B2O3	5.0	5.0	5.0	5.0	5.0	5.0
	Al2O3	5.0	5.0	5.0	5.0	5.0	5.0
	MgO	5.0	5.0	5.0	5.0	5.0	5.0
	CaO	3.0	3.0	5.0	5.0	5.0	5.0
	ZnO	—	—	—	—	—	—
	RO	8.0	8.0	10.0	10.0	10.0	10.0
	LI2O	2.0	0.0	2.0	2.0	2.0	4.0
	Na2O	10.0	12.0	11.0	9.0	7.0	9.0
	K2O	5.0	5.0	2.0	4.0	6.0	2.0
	R'2O	17.0	17.0	15.0	15.0	15.0	15.0
	TiO2	0.0	0.0	0.0	0.0	0.0	0.0
	ZrO2	—	—	—	—	—	—
	SiO2+B2O3+Al2O3	75.0	75.0	75.0	75.0	75.0	75.0
	B2O3/Al2O3	1.0	1.0	1.0	1.0	1.0	1.0
	RO+R'2O	25.0	25.0	25.0	25.0	25.0	25.0
	SiO2+B2O3+Al2O3+RO+R'2O	100.0	100.0	100.0	100.0	100.0	100.0
	SiO2+B2O3+Al2O3+R'2O	92.0	92.0	90.0	90.0	90.0	90.0
	SiO2+B2O3+Al2O3+RO +R'2O+TiO2+ZrO2	100.0	100.0	100.0	100.0	100.0	100.0
	合 計	100.0	100.0	100.0	100.0	100.0	100.0
ガラス転移点 Tg[℃]		511	540	524	526	523	507
屈伏点 Td [℃]		581	608	599	593	595	572
熱膨張係数 $\alpha \times 10^{-7}$[/℃]		92	95	83	85	87	106
密度 [g/cm³]		2.473	2.477	2.485	2.482	2.477	2.478
ヤング率 E[GPa]		76.71	74.00	78.97	78.28	77.13	80.71
剛性率G [GPa]		31.62	30.48	32.50	32.21	31.74	33.26
水中	押し込み荷重 [gF]	1000	1000	1000	1000	1000	1000
	脆さ指標値 B [$\mu m^{-1/2}$]	9.9	9.8	9.8	10.0	10.6	10.0
	ビッカース硬度 Hv [GPa]	5.8	5.3	5.7	5.8	5.8	5.8
	破壊靭性 Kc [MPa/$m^{1/2}$]	0.58	0.56	0.60	0.58	0.55	0.59
	プロバビリティ	100	100	100	100	100	100
乾燥雰囲気 N2	押し込み荷重 [gF]	5980	5980	5980	5980	5980	5980
	脆さ指標値 B [$\mu m^{-1/2}$]	5.0	4.8	5.4	5.6	5.5	5.1
	ビッカース硬度 Hv [GPa]	5.6	5.1	5.5	5.7	5.7	5.6
	破壊靭性 Ko [MPa/$m^{1/2}$]	1.13	1.14	1.08	1.04	1.04	1.15
	プロバビリティ	100	100	100	100	100	100

【００７９】

【表７】

表 7

		実施例					
		37	38	39	40	41	42
組成（モル%）	SiO2	65.0	65.0	65.0	65.0	65.0	65.0
	B2O3	5.0	5.0	5.0	5.0	5.0	5.0
	Al2O3	5.0	5.0	5.0	5.0	5.0	5.0
	MgO	5.0	5.0	5.0	5.0	5.0	5.0
	CaO	5.0	5.0	5.0	5.0	5.0	5.0
	ZnO	—	—	—	—	—	0.0
	RO	10.0	10.0	10.0	10.0	10.0	10.0
	Li2O	4.0	4.0	6.0	6.0	6.0	8.0
	Na2O	7.0	5.0	7.0	5.0	3.0	5.0
	K2O	4.0	6.0	2.0	4.0	6.0	2.0
	R'2O	15.0	15.0	15.0	15.0	15.0	15.0
	TiO2	0.0	0.0	0.0	0.0	0.0	0.0
	ZrO2	—	—	—	—	—	0.0
	SiO2+B2O3+Al2O3	75.0	75.0	75.0	75.0	75.0	75.0
	B2O3/Al2O3	1.0	1.0	1.0	1.0	1.0	1.0
	RO+R'2O	25.0	25.0	25.0	25.0	25.0	25.0
	SiO2+B2O3+Al2O3+RO+R'2O	100.0	100.0	100.0	100.0	100.0	100.0
	SiO2+B2O3+Al2O3+R'2O	90.0	90.0	90.0	90.0	90.0	90.0
	SiO2+B2O3+Al2O3+RO+R'2O+TiO2+ZrO2	100.0	100.0	100.0	100.0	100.0	100.0
	合計	100.0	100.0	100.0	100.0	100.0	100.0
ガラス転移点 Tg[℃]		510	508	500	501	501	488
屈伏点 Td [℃]		579	579	566	568	571	552
熱膨張係数 $\alpha \times 10^{-7}$[/℃]		85	115	78	81	80	78
密度 [g/cm³]		2.474	2.469	2.470	2.465	2.460	2.464
ヤング率 E[GPa]		79.81	78.63	82.37	81.16	79.50	83.61
剛性率G [GPa]		32.88	32.38	33.93	33.44	32.76	34.44
水中	押し込み荷重 [gF]	1000	1000	1000	1000	1000	1000
	脆さ指標値 B [$\mu m^{-1/2}$]	10.1	10.5	10.0	9.9	10.4	9.9
	ビッカース硬度 Hv [GPa]	5.9	5.8	5.9	5.9	5.9	6.1
	破壊靭性 Kc [MPa/$m^{1/2}$]	0.58	0.56	0.60	0.60	0.57	0.61
	プロバビリティ	100	100	100	100	100	100
乾燥雰囲気 N2	押し込み荷重 [gF]	5980	5980	5980	5980	5980	5980
	脆さ指標値 B [$\mu m^{-1/2}$]	5.6	5.1	4.9	5.0	5.2	4.7
	ビッカース硬度 Hv [GPa]	5.7	5.5	5.6	5.6	5.6	5.5
	破壊靭性 Kc [MPa/$m^{1/2}$]	1.04	1.13	1.13	1.17	1.11	1.25
	プロバビリティ	100	100	100	100	100	100

【００８０】　　【表８】

表 8

		実施例					
		43	44	45	46	47	48
組成（モル%）	SiO2	65.0	65.0	65.0	65.0	65.0	65.0
	B2O3	5.0	5.0	5.0	5.0	5.0	5.0
	Al2O3	5.0	5.0	5.0	5.0	5.0	7.0
	MgO	5.0	5.0	5.0	5.0	5.0	5.0
	CaO	5.0	5.0	5.0	0.0	0.0	3.0
	ZnO	0.0	0.0	0.0	0.0	0.0	—
	RO	10.0	10.0	10.0	5.0	5.0	8.0
	Li2O	8.0	8.0	0.0	8.0	2.0	0.0
	Na2O	3.0	1.0	11.0	10.0	10.0	10.0
	K2O	4.0	6.0	4.0	2.0	5.0	5.0
	R'2O	15.0	15.0	15.0	20.0	17.0	15.0
	TiO2	0.0	0.0	0.0	0.0	0.0	0.0
	ZrO2	0.0	—	0.0	0.0	3.0	—
	SiO2+B2O3+Al2O3	75.0	75.0	75.0	75.0	75.0	77.0
	B2O3/Al2O3	1.0	1.0	1.0	1.0	1.0	0.7
	RO+R'2O	25.0	25.0	25.0	25.0	22.0	23.0
	SiO2+B2O3+Al2O3+RO+R'2O	100.0	100.0	100.0	100.0	97.0	100.0
	SiO2+B2O3+Al2O3+R'2O	90.0	90.0	90.0	95.0	92.0	92.0
	SiO2+B2O3+Al2O3+RO+R'2O+TiO2+ZrO2	100.0	100.0	100.0	100.0	100.0	100.0
	合計	100.0	100.0	100.0	100.0	100.0	100.0
ガラス転移点 Tg[℃]		494	504	552	474	533	536
屈伏点 Td [℃]		561	577	622	536	615	596
熱膨張係数 $\alpha \times 10^{-7}$[/℃]		81	73	89	91	87	122
密度 [g/cm³]		2.458	2.446	2.485	2.449	2.525	2.462
ヤング率 E[GPa]		82.10	79.04	75.27	79.92	77.29	71.94
剛性率G [GPa]		33.82	32.64	30.96	32.45	31.61	29.58
水中	押し込み荷重 [gF]	1000	1000	1000	1000	1000	1000
	脆さ指標値 B [$\mu m^{-1/2}$]	9.8	9.9	9.9	9.5	9.0	8.5
	ビッカース硬度 Hv [GPa]	5.9	5.7	5.8	—	—	5.1
	破壊靭性 Kc [MPa/$m^{1/2}$]	0.61	0.59	0.58	—	—	0.63
	プロバビリティ	100	100	100	—	—	100
乾燥雰囲気 N2	押し込み荷重 [gF]	5980	5980	5980	5980	5980	5980
	脆さ指標値 B [$\mu m^{-1/2}$]	4.7	4.8	5.7	4.6	4.3	5.1
	ビッカース硬度 Hv [GPa]	5.6	5.4	5.5	5.6	5.5	5.2
	破壊靭性 Kc [MPa/$m^{1/2}$]	1.25	1.19	0.99	1.27	1.30	1.06
	プロバビリティ	100	100	100	100	100	100

【００８１】　【表９】

表 9

		実施例						
		49	50	51	52	53	54	55
組成（モル%）	SiO2	65.0	65.0	65.0	65.0	65.4	65.4	65.4
	B2O3	5.0	5.0	7.5	10.0	0.0	0.0	0.0
	Al2O3	7.5	10.0	2.5	0.0	8.6	8.6	8.6
	MgO	10.0	10.0	5.0	5.0	0.0	0.0	0.0
	CaO	0.0	0.0	5.0	5.0	0.0	0.0	0.0
	ZnO	0.0	0.0	—	—	0.0	0.0	0.0
	RO	10.0	10.0	10.0	10.0	0.0	0.0	0.0
	Li2O	0.0	0.0	0.0	0.0	12.5	7.5	0.0
	Na2O	7.5	5.0	10.0	10.0	10.5	10.5	13.0
	K2O	5.0	5.0	5.0	5.0	0.0	5.0	10.0
	R'2O	12.5	10.0	15.0	15.0	23.0	23.0	23.0
	TiO2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	ZrO2	—	—	—	—	3.0	3.0	3.0
	SiO2+B2O3+Al2O3	77.5	80.0	75.0	75.0	74.0	74.0	74.0
	B2O3/Al2O3	0.7	0.5	3.0	—	0.0	0.0	0.0
	RO+R'2O	22.5	20.0	25.0	25.0	23.0	23.0	23.0
	SiO2+B2O3+Al2O3+RO+R'2O	100.0	100.0	100.0	100.0	97.0	97.0	97.0
	SiO2+B2O3+Al2O3+R'2O	90.0	90.0	90.0	90.0	97.0	97.0	97.0
	SiO2+B2O3+Al2O3+RO+R'2O+TiO2+ZrO2	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	合 計	100.0	100.0	100.0	100.0	100.0	100.0	100.0
ガラス転移点 Tg[℃]		577	631	557	559	498	491	534
屈伏点 Td [℃]		658	752	622	623	564	568	629
熱膨張係数 $\alpha \times 10^{-7}$[/℃]		76	70	87	89	89	116	113
密度 [g/cm³]		2.419	2.399	2.486	2.493	2.511	2.523	2.537
ヤング率 E[GPa]		71.46	70.77	76.10	78.41	84.13	79.70	71.31
剛性率 G [GPa]		29.51	29.49	31.35	32.37	34.71	32.82	29.30
水中	押し込み荷重 [gF]	1000	1000	1000	1000	1000	1000	1000
	脆さ指標値 B [$\mu m^{-1/2}$]	8.4	7.1	10.4	13.2	7.8	8.4	7.9
	ビッカース硬度 Hv [GPa]	5.6	5.1	5.4	5.9	5.6	5.7	5.4
	破壊靭性 Kc [MPa/$m^{1/2}$]	0.96	0.76	0.54	0.44	0.77	0.70	0.69
	プロバビリティ	100	100	100	100	100	100	100
乾燥雰囲気 N2	押し込み荷重 [gF]	5980	5980	5980	5980	5980	5980	5980
	脆さ保存性 B[$\mu m^{-1/2}$]	5.2	5.3	4.9	5.5	4.3	5.0	5.2
	ビッカース硬度 Hv [GPa]	5.6	5.2	5.2	5.5	5.4	5.5	4.9
	破壊靭性 Kc [MPa/$m^{1/2}$]	1.05	1.01	1.13	1.05	1.37	1.16	1.02
	プロバビリティ	100	100	100	100	100	100	100

【００８２】

【表１０】

表 10

		実施例					
		56	57	58	59	60	61
組成（モル%）	SiO2	48.0	53.2	57.0	59.0	59.0	59.0
	B2O3	16.0	14.4	9.5	9.0	9.5	10.5
	Al2O3	16.0	14.4	9.5	9.0	9.5	10.5
	MgO	0.0	0.0	2.0	3.0	2.0	0.0
	CaO	0.0	0.0	0.0	0.0	0.0	0.0
	ZnO	0.0	0.0	0.0	0.0	0.0	0.0
	RO	0.0	0.0	2.0	3.0	2.0	0.0
	Li2O	10.0	10.0	9.0	10.0	9.0	10.0
	Na2O	8.0	6.0	9.0	10.0	9.0	5.0
	K2O	2.0	2.0	2.0	0.0	2.0	5.0
	R'2O	20.0	18.0	20.0	20.0	20.0	20.0
	TiO2	0.0	0.0	0.0	0.0	0.0	0.0
	ZrO2	0.0	0.0	2.0	0.0	0.0	0.0
	SiO2+B2O3+Al2O3	80.0	82.0	76.0	77.0	78.0	80.0
	B2O3/Al2O3	1.0	1.0	1.0	1.0	1.0	1.0
	RO+R'2O	20.0	18.0	22.0	23.0	22.0	20.0
	SiO2+B2O3+Al2O3+RO+R'2O	100.0	100.0	98.0	100.0	100.0	100.0
	SiO2+B2O3+Al2O3+R'2O	100.0	100.0	96.0	97.0	98.0	100.0
	SiO2+B2O3+Al2O3+RO+R'2O+TiO2+ZrO2	100.0	100.0	100.0	100.0	100.0	100.0
	合計	100.0	100.0	100.0	100.0	100.0	100.0
ガラス転移点 Tg[℃]		475	483	484	483	476	473
屈伏点 Td [℃]		525	539	543	534	530	529
熱膨張係数 $\alpha \times 10^{-7}$[/℃]		90	77	89	84	87	84
密度 [g/cm³]		2.382	2.359	2.492	2.456	2.444	2.415
ヤング率 E[GPa]		72.62	71.84	81.35	83.13	80.45	77.88
剛性率 G [GPa]		29.16	28.96	32.96	33.70	32.73	31.71
乾燥雰囲気 N2	押し込み荷重 [gF]	6952	6952	6952	6952	6952	6952
	脆さ保存性 B[$\mu m^{-1/2}$]	3.5	3.1	3.9	3.8	3.7	3.8
	ビッカース硬度 Hv [GPa]	5.2	5.0	5.8	5.8	5.7	5.5
	破壊靭性 Kc [MPa/$m^{1/2}$]	1.54	1.71	1.53	1.57	1.56	1.51
	プロバビリティ	20	60	100	100	100	80

【００８３】

30　【表１１】

表 11

		実施例					
		62	63	64	65	66	67
組成（モル%）	SiO2	59.0	60.0	60.0	60.0	60.0	61.0
	B2O3	10.5	0.0	5.0	7.5	9.0	5.0
	Al2O3	10.5	15.0	15.0	7.5	9.0	12.0
	MgO	0.0	5.0	0.0	5.0	0.0	5.0
	CaO	0.0	0.0	0.0	0.0	0.0	0.0
	ZnO	0.0	0.0	0.0	0.0	0.0	0.0
	RO	0.0	5.0	0.0	5.0	0.0	5.0
	Li2O	10.0	9.0	9.0	10.0	9.0	10.0
	Na2O	10.0	9.0	9.0	5.0	9.0	5.0
	K2O	0.0	2.0	2.0	5.0	2.0	2.0
	R'2O	20.0	20.0	20.0	20.0	20.0	17.0
	TiO2	0.0	0.0	0.0	0.0	0.0	0.0
	ZrO2	0.0	0.0	0.0	0.0	2.0	0.0
	SiO2+B2O3+Al2O3	80.0	75.0	80.0	75.0	78.0	78.0
	B2O3/Al2O3	1.0	0.0	0.3	1.0	1.0	0.4
	RO+R'2O	20.0	25.0	20.0	25.0	20.0	22.0
	SiO2+B2O3+Al2O3+RO+R'2O	100.0	100.0	100.0	100.0	98.0	100.0
	SiO2+B2O3+Al2O3+R'2O	100.0	95.0	100.0	95.0	98.0	95.0
	SiO2+B2O3+Al2O3+RO+R'2O+TiO2+ZrO2	100.0	100.0	100.0	100.0	100.0	100.0
	合 計	100.0	100.0	100.0	100.0	100.0	100.0
ガラス転移点 Tg[℃]		485	530	491	464	487	495
屈伏点 Td [℃]		538	610	560	535	545	564
熱膨張係数 $\alpha \times 10^{-7}$[/℃]		82	93	88	91	87	78
密度 [g/cm³]		2.420	2.464	2.428	2.428	2.48	2.422
ヤング率 E[GPa]		80.13	82.79	78.75	79.23	81.53	80.56
剛性率 G [GPa]		32.65	33.71	32.05	32.38	33.22	32.77
乾燥雰囲気 N2	押し込み荷重 [gF]	6952	6952	6952	6952	6952	6952
	脆さ保存性 B[$\mu m^{-1/3}$]	3.5	4.2	4.1	4.2	3.9	3.9
	ビッカース硬度 Hv [GPa]	5.5	5.7	5.4	5.8	5.8	5.5
	破壊靭性 Kc [MPa/$m^{1/2}$]	1.65	—	—	1.40	1.50	—
	プロバビリティ	75	80	100	60	80	100

【００８４】

30　【表１２】

表 12

		実施例					
		68	69	70	71	72	73
組成（モル%）	SiO2	61.0	62.0	63.0	63.0	63.0	65.0
	B2O3	9.5	7.0	7.5	8.5	8.5	2.5
	Al2O3	9.5	7.0	7.5	8.5	8.5	10.5
	MgO	0.0	2.0	2.0	0.0	0.0	5.0
	CaO	0.0	—	0.0	0.0	0.0	0.0
	ZnO	0.0	—	0.0	0.0	0.0	0.0
	RO	0.0	2.0	2.0	0.0	0.0	5.0
	Li2O	10.0	9.0	9.0	10.0	9.0	10.0
	Na2O	10.0	9.0	9.0	10.0	9.0	5.0
	K2O	0.0	2.0	2.0	0.0	2.0	2.0
	R'2O	20.0	20.0	20.0	20.0	20.0	17.0
	TiO2	0.0	—	0.0	0.0	0.0	0.0
	ZrO2	0.0	2.0	0.0	0.0	0.0	0.0
	SiO2+B2O3+Al2O3	80.0	76.0	78.0	80.0	80.0	78.0
	B2O3/Al2O3	1.0	1.0	1.0	1.0	1.0	0.2
	RO+R'2O	20.0	22.0	22.0	20.0	20.0	22.0
	SiO2+B2O3+Al2O3+RO+R'2O	100.0	98.0	100.0	100.0	100.0	100.0
	SiO2+B2O3+Al2O3+R'2O	100.0	96.0	98.0	100.0	100.0	95.0
	SiO2+B2O3+Al2O3+RO+R'2O+TiO2+ZrO2	100.0	100.0	100.0	100.0	100.0	100.0
	合計	100.0	100.0	100.0	100.0	100.0	100.0
ガラス転移点 Tg[℃]		483	480	471	480	479	493
屈伏点 Td [℃]		535	540	528	533	537	568
熱膨張係数 $\alpha \times 10^{-7}$[/℃]		85	86	89	84	89	80
密度 [g/cm³]		2.427	2.450	2.448	2.431	2.431	2.421
ヤング率 E[GPa]		81.00	83.00	80.96	81.57	79.91	80.67
剛性率 G [GPa]		33.06	—	33.00	33.37	32.71	33.09
乾燥雰囲気 N2	押し込み荷重 [gF]	6952	6952	6952	6952	6952	6952
	脆さ保存性 B[$\mu m^{-1/3}$]	3.7	4.0	4.1	3.9	3.8	4.1
	ビッカース硬度 Hv [GPa]	5.6	—	5.7	5.5	5.5	5.7
	破壊靭性 Kc [MPa/$m^{1/2}$]	1.58	—	1.44	1.51	1.52	—
	プロバビリティ	40	—	100	100	100	100

【００８５】
【表１３】

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表 13

		実施例			
		74	75	76	77
組成（モル%）	SiO2	65.0	65.0	65.0	65.0
	B2O3	5.0	7.5	7.5	7.5
	Al2O3	5.0	7.5	7.5	7.5
	MgO	0.0	0.0	0.0	0.0
	CaO	0.0	0.0	0.0	0.0
	ZnO	0.0	0.0	0.0	0.0
	RO	0.0	0.0	0.0	0.0
	Li2O	10.0	5.0	10.0	10.0
	Na2O	10.0	10.0	5.0	7.5
	K2O	5.0	5.0	5.0	2.5
	R'2O	25.0	20.0	20.0	20.0
	TiO2	0.0	0.0	0.0	0.0
	ZrO2	0.0	0.0	0.0	0.0
	SiO2+B2O3+Al2O3	75.0	80.0	80.0	80.0
	B2O3/Al2O3	1.0	1.0	1.0	1.0
	RO+R'2O	25.0	20.0	20.0	20.0
	SiO2+B2O3+Al2O3+RO+R'2O	100.0	100.0	100.0	100.0
	SiO2+B2O3+Al2O3+R'2O	100.0	100.0	100.0	100.0
	SiO2+B2O3+Al2O3+RO+R'2O+TiO2+ZrO2	100.0	100.0	100.0	100.0
	合 計	100.0	100.0	100.0	100.0
ガラス転移点 Tg[℃]		451	482	475	472
屈伏点 Td [℃]		510	541	538	529
熱膨張係数 $\alpha\times10^{-7}$[/℃]		107	95	85	84
密度 [g/cm³]		2.453	2.452	2.420	2.429
ヤング率 E[GPa]		77.98	77.81	78.83	80.62
剛性率 G [GPa]		31.79	31.87	32.27	33.01
乾燥雰囲気 N2	押し込み荷重 [gF]	6952	6952	6952	6952
	脆さ保存性 B[$\mu m^{-1/3}$]	4.0	4.3	4.1	3.9
	ビッカース硬度 Hv [GPa]	5.4	5.4	5.7	5.6
	破壊靭性 Kc [MPa/$m^{1/2}$]	1.42	1.31	1.42	1.51
	プロバビリティ	100	100	100	80

【００８６】
【表１４】

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表 14

		実施例			
		78	79	80	81
組成（モル%）	SiO2	65.0	65.0	65.0	65.0
	B2O3	7.5	7.5	7.5	10.0
	Al2O3	7.5	7.5	7.5	0.0
	MgO	0.0	0.0	0.0	5.0
	CaO	0.0	0.0	0.0	0.0
	ZnO	0.0	0.0	0.0	0.0
	RO	0.0	0.0	0.0	5.0
	Li2O	10.0	10.0	9.0	5.0
	Na2O	10.0	10.0	9.0	10.0
	K2O	0.0	0.0	2.0	5.0
	R'2O	20.0	20.0	20.0	20.0
	TiO2	0.0	0.0	0.0	0.0
	ZrO2	0.0	0.0	0.0	0.0
	SiO2+B2O3+Al2O3	80.0	80.0	80.0	75.0
	B2O3/Al2O3	1.0	1.0	1.0	—
	RO+R'2O	20.0	20.0	20.0	25.0
	SiO2+B2O3+Al2O3+RO+R'2O	100.0	100.0	100.0	100.0
	SiO2+B2O3+Al2O3+R'2O	100.0	100.0	100.0	95.0
	SiO2+B2O3+Al2O3+RO+R'2O+TiO2+ZrO2	100.0	100.0	100.0	100.0
	合 計	100.0	100.0	100.0	100.0
ガラス転移点 Tg[℃]		483	478	477	484
屈伏点 Td [℃]		544	533	533	541
熱膨張係数 $\alpha\times10^{-7}$[/℃]		83	83	85	98
密度 [g/cm³]		2.440	2.431	2.434	2.477
ヤング率 E[GPa]		82.07	82.00	80.81	80.64
剛性率 G [GPa]		33.58	33.65	33.15	33.02
乾燥雰囲気 N2	押し込み荷重 [gF]	1000	1000	1000	1000
	脆さ保存性 B[$\mu m^{-1/3}$]	3.9	3.8	3.9	4.2
	ビッカース硬度 Hv [GPa]	5.6	5.6	5.7	5.7
	破壊靭性 Kc [MPa/$m^{1/2}$]	1.52	1.53	1.48	1.39
	プロバビリティ	80	100	100	100

【００８７】比較例１～３
特開平１０－１５８０２８号公報に記載されているガラスについて、その物性を表１５に示した。
【００８８】
【表１５】

表 15

		比較例 1	比較例 2	比較例 3
組成（モル%）	SiO2	69.28	69.94	68.94
	B2O3	—	—	—
	Al2O3	2.5	2.51	4.24
	MgO	6.97	6.96	5.77
	CaO	7.97	8	8.28
	SrO	—	0.24	1.81
	Li2O	—	—	—
	Na2O	1.96	4.93	1.46
	K2O	9.56	6.75	9.25
	TiO2	—	—	—
	ZrO2	1.76	0.66	0.26
	合 計	100.0	100.0	100.0
ガラス転移点 Tg[℃]		657	623	658
屈伏点 Td [℃]		780	710	732
熱膨張係数 $\alpha \times 10^{-7}$[/℃]		86.8	85.8	82.8
密度 [g/cm^3]		2.52	2.49	2.51
ヤング率 E[GPa]		80.5	80.3	81.5
押し込み荷重 [gF]		1000	1000	1000
脆さ指標値 B [$\mu m^{-1/2}$]		7.2	7.2	7.1
ビッカース硬度 Hv [GPa]		6.1	6.1	6.2
破壊靭性 Kc [MPa/m$^{1/2}$]		0.90	0.91	1.05

【００８９】実施例８２

実施例１～８１で得られたガラスを用い、（１）粗ラッピング工程（粗研削工程）、（２）形状加工工程、（３）精ラッピング工程（精研削工程）、（４）端面鏡面加工工程、（５）第１研磨工程、（６）第２研磨工程、（７）検査工程及び（８）磁気ディスク製造工程を順次行うことにより、情報記録媒体用ガラス基板を作製し、さらに磁気ディスクを製造した。なお、上記（４）端面鏡面加工工程から（６）第２研磨工程までの研磨装置に使用する研磨液の水は、純水を使用した。

【００９０】（１）粗ラッピング工程

まず、溶融ガラスから上型、下型、胴型を用いたダイレクトプレスにより直径９６mmφ、厚さ１．５mmの円盤状のガラス基板を得た。なお、この場合、ダイレクトプレス以外に、ダウンドロー法やフロート法で形成したシートガラスから研削砥石で切り出して円盤状のガラス基板を得てもよい。

【００９１】次いで、ガラス基板に寸法精度及び形状精度を向上させるためラッピング工程を行った。このラッピング工程は両面ラッピング装置を用い、粒度＃４００の砥粒を用いて行なった。具体的には、はじめに粒度＃４００のアルミナ砥粒を用い、荷重を９８０N程度に設定して、サンギアとインターナルギアを回転させることによって、キャリア内に収納したガラス基板の両面を面精度０～１μm、表面粗さ（Ｒｍａｘ）６μm程度にラッピングした。

【００９２】（２）形状加工工程

次に、円筒状の砥石を用いてガラス基板の中央部分に孔を空けると共に、外周端面の研削をして直径を９５mmφとした後、外周端面および内周端面に所定の面取り加工を施した。この際のガラス基板端面の表面粗さは、Ｒｍａｘで４μm程度であった。

【００９３】（３）精ラッピング工程

次に、砥粒の粒度を＃１０００に変え、ガラス基板表面をラッピングすることにより、表面粗さをＲｍａｘで２μm程度、Ｒａで０．２μm程度とした。上記ラッピング工程を終えたガラス基板を、中性洗剤、水の各洗浄槽（超音波印加）に順次浸漬して、超音波洗浄を行なった。

【００９４】（４）端面鏡面加工工程

次いで、ブラシ研磨により、ガラス基板を回転させながらガラス基板の端面（内周、外周）の表面の粗さを、Ｒｍａｘで１μm、Ｒａで０．３μm程度に研磨した。そして、上記端面鏡面加工を終えたガラス基板の表面を水洗浄した。

【００９５】（５）第１研磨工程

次に、上述したラッピング工程で残留した傷や歪みを除去するため第１研磨工程を両面研磨装置を用いて行なった。両面研磨装置においては、研磨パッドが貼り付けられた上下定盤の間にキャリアにより保持したガラス基板を密着させ、このキャリアをサンギアとインターナルギアとに噛合させ、上記ガラス基板を上下定盤によって挟圧する。その後、研磨パッドとガラス基板の研磨面との間に研磨液を供給して回転させることによって、ガラス基板が定盤上で自転しながら公転して両面を同時に研磨加工するものである。以下、実施例で使用する両面研磨

装置としては同一装置を用いた。

【００９６】具体的には、ポリシャとして硬質ポリシャ（硬質発泡ウレタン）を用い、研磨工程を実施した。研磨条件は、研磨液として酸化セリウム（平均粒径１．３μｍ）＋純水とし、荷重：９．８ｍＮ／ｍｍ²、研磨時間：１５分とした。上記第１研磨工程を終えたガラス基板を、中性洗剤、純水、純水、イソプロピルアルコール（ＩＰＡ）、ＩＰＡ（蒸気乾燥）の各洗浄槽に順次浸漬して、超音波洗浄し、乾燥した。

【００９７】（６）第２研磨工程

次に第１研磨工程で使用したものと同じタイプの両面研磨装置を用い、ポリシャを軟質ポリシャ（スウェードパット）に変えて、第２研磨工程を実施した。この第２研磨工程は、上述した第１研磨工程で得られた平坦な表面を維持しつつ、例えば表面粗さＲａを１．０～０．３μｍ程度以下まで低減させることを目的とするものである。研磨条件は、研磨液として酸化セリウム（平均粒径０．８μｍ）＋純水とし、荷重：９．８ｍＮ／ｍｍ²、研磨時間を５分とした。上記第２研磨工程を終えたガラス基板を、中性洗剤、純水、純水、ＩＰＡ、ＩＰＡ（蒸気乾燥）の各洗浄槽に順次浸漬して、超音波洗浄し、乾燥した。本実施例のガラス基板は、化学強化層を有さないが、前記研磨工程中や工程と工程のハンドリング時においてガラス基板が破壊しなかった。

【００９８】（７）検査工程

次に、上記乾燥を終えたガラス基板表面の目視検査及び光の反射・散乱・透過を利用した精密検査を実施した。その結果、ガラス基板表面に傷等の欠陥は発見されなかった。また、上記工程を経て得られたガラス基板の主表面の表面粗さを原子間力顕微鏡（ＡＦＭ）にて測定したところ、Ｒｍａｘ＝２．１３ｎｍ、Ｒａ＝０．２０ｎｍと超平滑な表面を持つ磁気ディスク用ガラス基板を得た。

【００９９】（８）磁気ディスク製造工程

上記工程を経て得られた磁気ディスク用ガラス基板の両主表面に、インライン型スパッタリング装置を用いて、ＮｉＡｌシード層、ＣｒＶ下地層、ＣｏＰｔＣｒＢ磁性層、水素化カーボン保護層を順次成膜し、さらにディップ法によりパーフルオロポリエーテル潤滑層を成膜して磁気ディスクを得た。得られた磁気ディスクについて、タッチダウンハイト試験を実施したところ、タッチダウンハイトが５ｎｍと良好な値を示した。また、ロードアンロード試験（１０万回）を行なってもヘッドがクラッシュすることがなかった。

【０１００】実施例８３

実施例８２における前記（６）第２研磨工程と前記（７）の検査工程の間に下記化学強化工程を行ったこと以外は、実施例８２と同様に磁気ディスクの製造を行った。化学強化工程は硝酸カリウムと硝酸ナトリウムの混合物を含む化学強化液を用意し、この化学強化溶液を３８０℃に加熱し、上記洗浄・乾燥済みのガラス基板を約４時間浸漬して化学強化処理を行ない、化学強化を終えたガラス基板を硫酸、中性洗剤、純水、純水、ＩＰＡ、ＩＰＡ（蒸気乾燥）の各洗浄槽に順次浸漬して、超音波洗浄し、乾燥した。

【０１０１】得られたガラス基板について、０．４ｍｍの薄片を切り出し、偏光顕微鏡を使用して測定したところ、化学強化層が形成されていることが確認された。本実施例のガラス基板は、前記研磨工程中や工程と工程のハンドリング時においてガラス基板が破壊しなかった。得られた磁気ディスクについて、タッチダウンハイト試験を実施したところ、タッチダウンハイトが５ｎｍと良好な値を示した。また、ロードアンロード試験（１０万回）を行なってもヘッドがクラッシュすることがなかった。

【０１０２】

【発明の効果】本発明の情報記録媒体用ガラス基板は、耐擦傷性に優れ、かつ軽量で破壊進行に対する抵抗力、すなわち破壊靭性が大きく、従来の情報記録媒体用ガラス基板に比べて磁気ディスクなどの生産加工中の破損や情報記録媒体としての使用中の破損が大幅に低減できる。さらに、ガラスとしても、市販のガラス基板と同程度または低いコストで大量生産できるため、安価な次世代磁気記録媒体用ガラス基板として大きく期待できる。

フロントページの続き

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